VOLUME 75 • JULY 1957 • NUMBER 1

A.M.A. ARCHIVES OF SURGERY

Principles of Medical Writing
Raymond Whitehead

Experimental Observations on Delayed Rupture and Secondary Hemorrhage from the Spleen
George W. Davis, H. Warner Webb, and John M. Howard

Renal Revascularization by Splenic Artery Implantation
H. Clinton Davis and Irwin S. Morse

Perforation of Stress Ulcers of the Esophagus Following Thermal Burns
John R. Derrick, Albert H. Wilkinson, and John M. Howard

Intrahepatic Cholangiojejunostomy (Longmire Procedure) in Carcinoma of Intrahepatic Bile Ducts
John L. Keeley and Arne E. Schairer

Gastroschisis
William B. Kiesewetter

Use of Radiophosphorus for Bone Vascularity Determinations
Patrick G. Laing, Albert B. Ferguson Jr., Laverne Vaughan, and Mary Grebner

Management of Intussusception in Infants and Children
Jules F. Langlet and Donald P. Chance

Serum Amylase Test in Differential Diagnosis of Freely Perforated Ulcer and Acute Pancreatitis
Sidney A. Rosenburg and Sermet Akgun

Surgical Pathology of Fungus Diseases
Jan Schwarz and Gerald L. Baum

Postoperative Respiratory Acidosis
Will C. Sealy, W. Glenn Young Jr., and John B. Hickam

Experiences with the Extirpated Canine Lung as a Biologic Oxygenator
George I. Thomas, John E. Jesseph, Niles C. Chapman, and K. Alvin Merendino

Aortic Commissurotomy for Calcific Aortic Stenosis Under Direct Vision Using Hypothermia
Benjamin Winter, Willard J. Zinn, and Bertram J. Allenstein

Herniated Lumbar Intervertebral Disks
H. G. Decker and S. W. Shapiro

Rectal Carcinoma Invading the Prostate Gland
Emil J. Ganem, David W. Wallwork, Leslie S. Jolliffe, and Julius Kay

Polyps of the Colon in Children
Donald L. Gordon, George A. Hallenbeck, Malcolm B. Dockerty, Roger L. J. Kennedy, and Raymond J. Jackman

Effect of Fibrinolytic Agents and Corticosteroid Hormones on Peritoneal Adhesions
Edmund M. Luttwak, Albert J. Behar, and Nathan J. Saltz

Myelographic Demonstration of Brachial Plexus Root Avulsion
R. A. Mendelsohn, I. H. Weiner, and J. M. Keegan

Cephalic Sympathetic Nerves
Albert Kuntz, Henry H. Hoffman, and Leonard M. Napolitano

Dimethicone (Silicone) Skin Protection in Surgical Patients
B. Noland Carter II and Roger Talbot Sherman

Preoperative Chlorpromazine in Poor-Risk and Uncooperative Mentally Deficient Patients
Theodore L. Jackson, John M. Carson, and George Tarjan

Primary Carcinoma of the Appendix
Jacob Rabinovitch, Phineas Rabinovitch, Philip Rosenblatt, and Harry Zisk

Ileal Transplant to Produce Perineal Stoma After Abdominoperineal Resection
Herbert F. Newman

Omphalocele in Siblings
Robert E. Rothenberg and Theodore Barnett

Plunging Goiter Made Evident by Valsalva's Maneuver
Everett Shocket and Theodore R. Hudson

Stensen's Duct: Key to Parotidectomy
Alex W. Ulin, Edward W. Ehrlich, and J. Winslow Smith

Congenital Cystic Dilatation of the Common Duct (Choledochal Cyst)
Luther M. Keith Jr., Jerome M. Rini, and L. Harold Martin

Congenital Abnormal Rotation of the Intestines
Joseph R. Wilder

Seat Belts and Abdominal Injury
Horace E. Campbell

The Community Surgeon Looks at General Surgery
J. P. Woodhall

Spigelian Hernia
Herman Pepper and Charles L. Geraci

Adenocarcinoma in a Meckel's Diverticulum with Perforation
G. C. Freeman

Carcinoid of the Ileum
Lawrence S. Mann and Robert D. Simpson

AMERICAN MEDICAL ASSOCIATION PUBLICATION

NOW—

A.C.M.I. CATHETERS INDIVIDUALLY SANITARY-SEALED

against pre-use contamination

SUPPLIED SINGLY OR IN BOXES OF 12

To preserve their immaculate quality during handling or storage, all ACMI catheters are now individually packaged in hermetically sealed, transparent envelopes — protecting them from contamination by dust, dirt or micro-organisms, and from undesirable atmospheric conditions. They may be readily autoclaved prior to removal for use. Each sealed envelope is clearly marked for catheter size, type, and catalogue number. Now, more than ever — for all of your catheter requirements, you can fully rely on ACMI.

FREDERICK J. WALLACE, *President*

American Cystoscope Makers, Inc.

NEW YORK, N. Y.

TABLE OF CONTENTS

VOLUME 75 JULY 1957 NUMBER 1

ORIGINAL ARTICLES

PAGE

Principles of Medical Writing
Raymond Whitehead, D.Sc., M.D., Manchester, England 1

Experimental Observations on Delayed Rupture and Secondary Hemorrhage from the Spleen
George W. Davis, M.D.; H. Warner Webb, M.D., and John M. Howard, M.D., Atlanta, Ga. 9

Renal Revascularization by Splenic Artery Implantation
H. Clinton Davis, M.D., and Irwin S. Morse, M.D., Miami, Fla. 13

Perforation of Stress Ulcers of the Esophagus Following Thermal Burns
John R. Derrick, M.D.; Albert H. Wilkinson, M.D., and John M. Howard, M.D., Atlanta, Ga. 17

Intrahepatic Cholangiojejunostomy (Longmire Procedure) in Carcinoma of Intrahepatic Bile Ducts
John L. Keeley, M.D., and Arne E. Schairer, M.D., Chicago 21

Gastroschisis
William B. Kiesewetter, M.D., Pittsburgh 28

Use of Radiophosphorus for Bone Vascularity Determinations
Patrick G. Laing, M.D.; Albert B. Ferguson Jr., M.D.; Laverne Vaughan, B.S., and Mary Grebner, B.S., Pittsburgh 31

Management of Intussusception in Infants and Children
Jules F. Langlet, M.D., and Donald P. Chance, M.D., Danville, Pa. 35

Serum Amylase Test in Differential Diagnosis of Freely Perforated Ulcer and Acute Pancreatitis
Sidney A. Rosenburg, M.D., and Sermet Akgun, M.D., Pittsburgh 41

Surgical Pathology of Fungus Diseases
Jan Schwarz, M.D., and Gerald L. Baum, M.D., Cincinnati 44

Postoperative Respiratory Acidosis
Will C. Sealy, M.D.; W. Glenn Young Jr., M.D., and John B. Hickam, M.D., Durham, N. C. 57

Experiences with the Extirpated Canine Lung as a Biologic Oxygenator
George I. Thomas, M.D.; John E. Jesseph, M.D.; Niles C. Chapman, M.D., and K. Alvin Merendino, M.D., Seattle 61

Aortic Commissurotomy for Calcific Aortic Stenosis Under Direct Vision Using Hypothermia
Benjamin Winter, M.D., F.R.C.S. (Edin.), F.R.C.S. (C), F.C.C.P., F.A.C.S.; Willard J. Zinn, M.D., and Bertram J. Allenstein, M.D., F.C.C.P., Los Angeles 69

Herniated Lumbar Intervertebral Disks
H. G. Decker, M.D., and S. W. Shapiro, M.D., Des Moines, Iowa 77

Rectal Carcinoma Invading the Prostate Gland
Emil J. Ganem, M.D.; David W. Wallwork, M.D.; Leslie S. Jolliffe, M.D., and Julius Kay, M.D., Lawrence, Mass. 85

Polyps of the Colon in Children
Donald L. Gordon, M.D.; George A. Hallenbeck, M.D.; Malcolm B. Dockerty, M.D.; Roger L. J. Kennedy, M.D., and Raymond J. Jackman, M.D., Rochester, Minn. 90

Effect of Fibrinolytic Agents and Corticosteroid Hormones on Peritoneal Adhesions
Edmund M. Luttwak, M.D.; Albert J. Behar, M.D., and Nathan J. Saltz, M.D., Jerusalem 96

Myelographic Demonstration of Brachial Plexus Root Avulsion
Major R. A. Mendelsohn, San Antonio, Texas; I. H. Weiner, M.D., Baltimore, and Major J. M. Keegan, San Antonio, Texas 102

Cephalic Sympathetic Nerves
Albert Kuntz, Ph.D., M.D.; Henry H. Hoffman, Ph.D., and Leonard M. Napolitano, Ph.D., St. Louis 108

Dimethicone (Silicone) Skin Protection in Surgical Patients
B. Noland Carter II, M.D., and Roger Talbot Sherman, M.D., Cincinnati 116

Preoperative Chlorpromazine in Poor-Risk and Uncooperative Mentally Deficient Patients
Theodore L. Jackson, M.D.; John M. Carson, D.D.S., and George Tarjan, M.D., Pomona, Calif. 118

Primary Carcinoma of the Appendix
Jacob Rabinovitch, M.D., C.M., Brooklyn; Phineas Rabinovitch, M.D., C.M., Montreal, Canada; Philip Rosenblatt, M.D., and Harry Zisk, M.D., Brooklyn 122

(Continued on Next Page)

A. M. A.
ARCHIVES OF SURGERY

Also the Official Publication of the Central Surgical Association and the Western Surgical Association

VOLUME 75 JULY 1957 NUMBER 1

COPYRIGHT, 1957, BY THE AMERICAN MEDICAL ASSOCIATION

EDITORIAL BOARD

WALTMAN WALTERS, Chairman, Rochester, Minn.
LESTER R. DRAGSTEDT, Chicago

ARTHUR W. ALLEN, Boston
ALFRED BLALOCK, Baltimore
FRANK HINMAN Jr., San Francisco
G. E. LINDSKOG, New Haven, Conn.
WALTER MADDOCK, Chicago
ALTON OCHSNER, New Orleans
HENRY KING RANSOM, Ann Arbor, Mich.
HENRY SWAN, Denver
BARNES WOODHALL, Durham, N. C.

AUSTIN SMITH, Editor, A. M. A. Scientific Publications
GILBERT S. COOPER, Managing Editor, Specialty Journals

TABLE OF CONTENTS (Continued)

Ileal Transplant to Produce Perineal Stoma After Abdominoperineal Resection
Herbert F. Newman, M.D., New York 128

Omphalocele in Siblings
Robert E. Rothenberg, M.D., and Theodore Barnett, M.D., Brooklyn 131

Plunging Goiter Made Evident by Valsalva's Maneuver
Everett Shocket, M.D., and Theodore R. Hudson, M.D., Chicago 135

Stensen's Duct: Key to Parotidectomy
Alex W. Ulin, M.D.; Edward W. Ehrlich, M.D., and J. Winslow Smith, M.D., Philadelphia 138

Congenital Cystic Dilatation of the Common Duct (Choledochal Cyst)
Luther M. Keith Jr., M.D., Columbus, Ohio; Jerome M. Rini, M.D., Portsmouth, Ohio, and L. Harold Martin, M.D., Ashland, Ohio 143

Congenital Abnormal Rotation of the Intestines
Joseph R. Wilder, M.D., New York 146

EDITORIALS

Seat Belts and Abdominal Injury
Horace E. Campbell, M.D., Denver 150

The Community Surgeon Looks at General Surgery
J. P. Woodhall, M.D., Macon, Ga. 152

CASE REPORTS

Spigelian Hernia
Herman Pepper, M.D., and Charles L. Geraci, M.D., Redwood City, Calif. 156

Adenocarcinoma in a Meckel's Diverticulum with Perforation
G. C. Freeman, M.D., Honolulu, Hawaii 158

Carcinoid of the Ileum
Lawrence S. Mann, M.D., and Robert D. Simpson, M.D., Chicago 161

To avoid the discomfort of distention

URECHOLINE®
CHLORIDE

(BETHANECHOL CHLORIDE)

Prophylactic use of URECHOLINE Tablets considerably simplifies the management of postoperative abdominal distention. Clinical studies[1] show improved gastrointestinal tone and increased peristalsis with expulsion of flatus (often within thirty minutes), following oral administration of 10 to 20 mg. three to four times daily. In difficult cases, subcutaneous injection increases the number of successful responses.

Other indications: postoperative and postpartum urinary retention, hexamethonium-induced side effects, and megacolon.

Supplied: 5 mg. and 10 mg. tablets, bottles of 100, 1 cc ampuls, each containing 5 mg. of URECHOLINE Chloride.

Reference: 1. Stafford, C. E., Kugel, A. I., and Dederer, A.: *Surg., Gynec. & Obst.* **89**:570, Nov. 1949.

URECHOLINE IS A TRADEMARK OF MERCK & CO., INC.

MERCK SHARP & DOHME

DIVISION OF MERCK & CO. INC. PHILADELPHIA 1, PA.

Instructions to Contributors

Articles, book reviews, and other materials for publication should be addressed to the Chief Editor. Articles are accepted for publication on condition that they are contributed solely to this journal.

An original typescript of an article, with one carbon copy, should be provided; it must be double or triple spaced on one side of a standard size page, with at least a 1-inch margin at each edge. Another carbon copy should be retained by the author.

The main title of an article may not contain more than eighty characters and spaces; a subtitle may be of any length.

The author's name should be accompanied by the highest earned academic or medical degree which he holds. If academic connections are given for one author of an article, such connections must be given for all other authors of the article who have such connections.

If it is necessary to publish a recognizable photograph of a person, the author should notify the publisher that permission to publish has been obtained from the subject himself if an adult, or from the parents or guardian if a child. An illustration that has been published in another publication should be accompanied by a statement that permission for reproduction has been obtained from the author and the original publisher.

Oversized original illustrations should be photographed and a print on glossy paper submitted. Prints of a bluish tinge should be avoided. Large photomicrograph prints will be reduced in scale unless portions to be cropped are indicated by the author. The author should submit duplicate prints of roentgenograms and photomicrographs with the essential parts that are to be emphasized circled, as a guide to the photoengraver.

Charts and drawings should be in black ink on hard, white paper. Lettering should be large enough, uniform, and sharp enough to permit necessary reduction. Glossy prints of x-rays are requested. Paper clips should not be used on prints, since their mark shows in reproduction, as does writing on the back of prints with hard lead pencil or stiff pen. Labels should be prepared and pasted to the back of each illustration showing its number, the author's name, and an abbreviated title of the article, and plainly indicating the top. Charts and illustrations must have descriptive legends, grouped on a separate sheet. Tables must have captions. ILLUSTRATIONS SHOULD BE UNMOUNTED.

References to the literature should be limited to those used by the author in preparation of the article. They should be typed on a special page at the end of the manuscript. The citation should include, in the order given, name of author, title of article (with subtitle), name of periodical, with volume, page, month—day of month if weekly or biweekly—and year. References to books must contain, in the order given, name of author, title of book, city of publication, name of publisher, and year of publication.

AMERICAN MEDICAL ASSOCIATION

535 North Dearborn Street **Chicago 10**

BEFORE

AFTER

To help you show it better . . .

Choose this new Kodak 300 Projector . . .

With the Kodak Readymatic Slide Changer, you load your slides—up to 36 of them, 135, 828, or 1½-inch square, in cardboard mounts—and away you go. You start with a stack, you end with a stack—ready to show again. *List, $59.50.*

With the Automatic Magazine Changer, metal magazines, each holding up to 36 cardboard 2 x 2 slides, are always ready for use. Push-pull movement of changer handle projects slide, stores it, and automatically advances magazine to next slide. *List, $69.50.*

The new Kodak 300 Projector offers you big-projector brilliance without bulk or bother. A superb optical system with new-formula, 4-inch *f*/3.5 Kodak lens assures even illumination—wider pictures—crisp, clear, color-brilliant. New, turbo-type blower cools slides and optical system. Smart in design, easy to use, easy to carry and store.

See your photographic dealer, or write for details.

Prices are list, include Federal Tax where applicable, and are subject to change without notice.

EASTMAN KODAK COMPANY, Medical Division, Rochester 4, N. Y.

Serving medical progress through Photography and Radiography

Kodak

with Neraval–

prompt awakening

A PRACTICAL ADVANCE

Neraval
SODIUM

in thiobarbiturate anesthesia

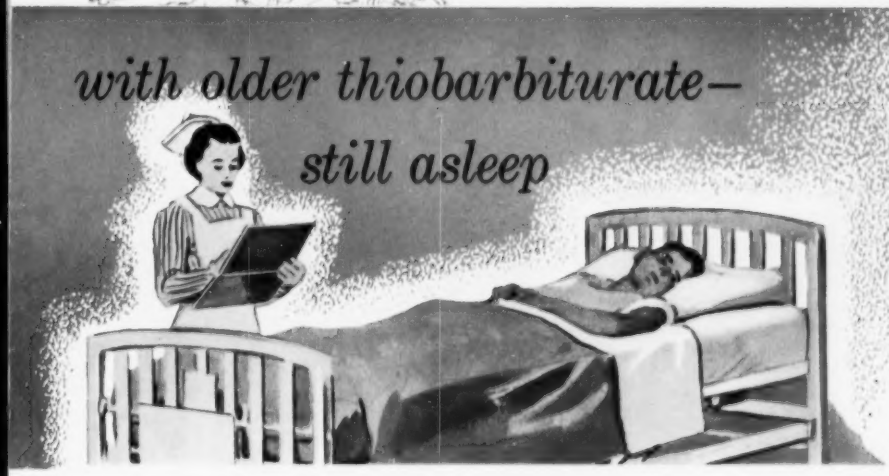
- *for oral surgery and related E.N.T. procedures*
- *outpatient clinic surgery* • *office instrumentation and biopsy*
- *psychiatric electronarcosis and other treatments*
- *orthopedic and fracture procedures in the clinic*

and many other situations
in which advantageous use can be made of
"...the shortest-acting thiobarbiturate so far...."[1]

Schering

NE-J-167

with older thiobarbiturate—still asleep



...distinctive among thiobarbiturates for its briefer action and lesser tendency to accumulation

NERAVAL is detoxified and eliminated faster than thiopental or thiamylal.[2-5] With NERAVAL, therefore, there is prompt, lucid awakening and a more rapid, notably more complete recovery than with other intravenous anesthetics.[1,3,5-8]

This characteristically swift NERAVAL recovery renders thiobarbiturate anesthesia pleasant for the patient and practical for the physician. For the patient—less postoperative "hangover" depression and incapacity; for the physician—less need of postanesthetic supervision and attention.[1,6-8] Use of NERAVAL simplifies the procedure and makes it more widely convenient for medical practice.

Since NERAVAL has lower milligram potency than earlier thiobarbiturates, it permits very quick lightening of anesthesia and requires higher dosage for equivalent anesthetic effect.

Packaging:
NERAVAL Sodium Sterile Powder:
vials of 1 Gm. and 2 Gm., boxes of 6 and 25;
vial of 5 Gm., boxes of 1 and 25.

Bibliography:
(1) Boone, J. D.; Muñoz, R., and Dillon, J. B.: Anesthesiology *17*:284, 1956. (2) Zima, O.; von Werder, F. and Hotovy, R.: Anaesthesist *3*:244, 1954. (3) Mersch, M. A.; Clarie, D'A., and Fitzpatrick, L. J.: J.M. Soc. New Jersey *53*:414, 1956. (4) Blake, M. W., and Perlman, P L.: J. Pharmacol. & Exper. Therap. *117*:287, 1956. (5) Irwin, S.; Stagg, R. D.; Dunbar, E., and Govier, W. M.: J. Pharmacol. & Exper. Therap. *116*:317, 1956. (6) Ayd, F. J., Jr.: Neraval: A new anesthetic for electroconvulsive therapy. Paper presented at annual meet., Electroshock Research Association, Chicago, Illinois, April 29, 1956. (7) Reifferscheid, M., and Dietmann, K.: Deutsche med. Wchnschr. *79*:638, 1954. (8) Houde, J.; Hudon, F., and Jacques, A.: Neraval (methitural sodium), Paper presented at Meet., Canad. Anaesth. Soc., Quebec City, P Q., May 5, 1956.

NERAVAL® Sodium, brand of methitural sodium.

SCHERING CORPORATION · Bloomfield, New Jersey

now available!

SteriSharps®

the first sterile, stainless-steel surgical blade

new SteriSharps valuable aid to surgeons and nurses...saves time, eliminates blade waste

Now available—the new SteriSharps surgical blade. Made of stainless steel, it has the sharpest, most uniform, most durable cutting edge made today. Comes to you ultrasonically cleaned and heat-sterilized for asepsis. Saves time, simplifies technic.

Surgeons can depend on *consistent sharpness* with SteriSharps. Electronic tests by ASR Sharpometer® assure uniform sharpness.

SteriSharps offer important economies, too. With SteriSharps only blades actually needed are used. They're unaffected by autoclaving, dry heat, solutions. Sealed packets can be re-autoclaved, stored indefinitely.

For details, write: ASR Hospital Division, Dept. AA, 380 Madison Ave., N. Y. 17, N. Y.

Blade Dispenser available. Your supplier has SteriSharps surgical blades in every design. Stainless steel dispenser shown above is yours free with every five gross.

Only SteriSharps offer all these advantages...

- Sharpest, most durable cutting edge
- Consistent sharpness in every blade
- SteriSharps will not corrode
- Can be re-autoclaved, stored in packs
- Sterile SteriSharps eliminate jars, racks and irritating solutions

A·S·R precision products

SteriSharps... the first sterile, stainless-steel surgical blade

Successful appetite control begins in the supermarket

If your overweight patient can resist the temptation to buy high calorie snacks, he's well on the road to successful weight reduction. You will find that one Dexedrine* Spansule† sustained release capsule taken in the morning controls appetite all day long—both at mealtimes and in the supermarket.

SKF

*T.M. Reg. U.S. Pat. Off. for dextro-amphetamine sulfate, S.K.F. †T.M. Reg. U.S. Pat. Off.

On the Utilization

of Oatmeal Carbohydrate

One of the distinguishing characteristics of oats is its relatively lower content of carbohydrate and its higher content of protein, when compared with other whole-grain cereals.[1] An important feature of the carbohydrate of oatmeal is its mode of utilization by the body.

Because it consists mainly of slowly available polysaccharides with relatively minor amounts of dextrins and simple sugars, the carbohydrate of oatmeal does not tend to cause a sudden, sharp increase in blood sugar. Instead, the complex carbohydrate molecules gradually release glucose into the blood stream and thus provide energy on a more sustained basis. Oatmeal is therefore logically recommended as an excellent breakfast dish for diabetics.[2]

The carbohydrate content of oats is almost completely digested and utilized. Cellulose, or cellulose-like material, representing only about 2 per cent of rolled oats in the dry form, provides a gelatinous residue which serves advantageously as nonirritant bulk in the lower intestine.

Whether eaten for therapeutic reasons during illness or for a good sturdy breakfast every day, oatmeal and milk (skim or whole) assures high biologic quality protein, vitamins, and essential minerals, in addition to ease of nutritional utilization.

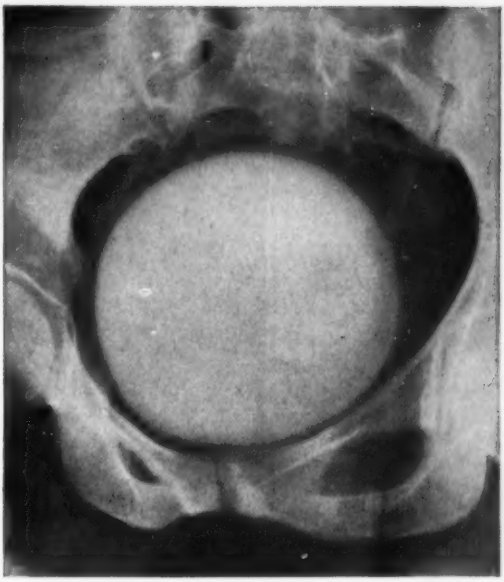
Quaker Oats and Mother's Oats, the two brands of oatmeal offered by The Quaker Oats Company, are identical. Both brands are available in the Quick (cooks in one minute) and the Old-Fashioned varieties which are of equal nutrient value.

IN POSTSURGICAL NUTRITION oatmeal finds a well-merited place as soon as feedings no longer need be limited to clear liquids. Its high nutrient value and blandness aid in rapid, uneventful re-alimentation.

1. Kent-Jones, D.W.: Modern Cereal Chemistry, ed. 3, The Northern Publishing Co., Liverpool (1939).

2. Heupke, W., and Kolb, A.: Mechanism of the Beneficial Action of Alimentation of Oats in Diabetes, Deutsche Ztschr. Verdauungeskr. *13*:111 (1953).

The Quaker Oats Company
CHICAGO



Relieves postpartum retention aseptically

URECHOLINE®
CHLORIDE

(BETHANECHOL CHLORIDE)

URECHOLINE offers worthwhile therapeutic and psychologic advantages in managing urinary retention. In one study[1], prophylactic administration of URECHOLINE Tablets to 129 postpartum patients reduced the incidence of urinary retention 80 per cent. The dose was 15 to 30 mg. orally, commencing on the patient's return to her room after delivery, and repeated every four to six hours for the first twenty-four hours. This regimen usually eliminates the necessity for exposing the patient to the discomfort and risk of infection inherent in catheterization.

Supplied: 5 mg. and 10 mg. tablets, bottles of 100; 1-cc. ampuls, each containing 5 mg. of URECHOLINE Chloride.

Reference: 1. Fleming, A. R., *Am. J. Obst. & Gynec.*, **64** 134, July 1952.

URECHOLINE IS A TRADEMARK OF MERCK & CO., INC.

MSD

MERCK SHARP & DOHME

DIVISION OF MERCK & CO., INC., PHILADELPHIA 1, PA.

new SUPER HEADLIGHT

BY GOOD-LITE

- COOLER OPERATION
- 9 INTENSITIES OF LIGHT
- INCREASED SAFETY— UNDERWRITERS APPROVED

Medical men who have tried the new Super Good-Lite tell us there's nothing like it anywhere . . . at any price! Here's why: The entire unit has been redesigned by a group of *practicing surgeons* to provide a beam of light both brilliant and controllable . . . featuring nine intensities of light. The headlight construction and electrical circuit was designed for cooler operation and maximum safety.

The Good-Lite SUPER Headlight Includes:

- Good-Lite parallel beam headlight.
- 3 types of bulbs with 3 intensities of light each.
- Special Ground lens to intensify light.
- 2 mirrors (peep-hole and plain).
- Heavy duty transformer (20 watt) with 3 positions and off switch. Fuse in the secondary for your safety.
- Molded plastic connections.
- Gray plastic stainproof cords.
- Choice of 5 types of headbands.

Consult Your Surgical Supply Dealer or Send Coupon Today

GOOD-LITE MFG. CO.
7638 W. Madison St. • Forest Park, Ill.

Please send free catalog on Good--Lite Headlights to:

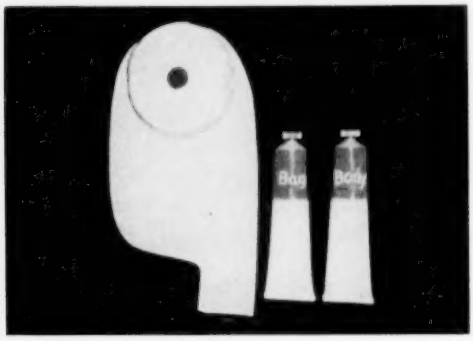
Dr. _____

Address _____

City _____ Zone _____ State _____

CUSTOM MADE

RUBBER ILLEOSTOMY COLOSTOMY APPLIANCES



- CHEMICALLY TREATED TO HELP ELIMINATE ODOR.
- CEMENTED TO BODY WITH OUR SPECIAL ADHESIVE CEMENT.

For information write to:

GERARD PRODUCTS

Dept. A

7875 Oakleaf Ave., Elmwood Park, Chicago 35, Ill.

C100 KAST KUTTER

SAFELY SHEARS CAST AND PADDING IN *ONE* POWERFUL CUT

S300 SPREADER

OPENS 5½" TO REMOVE CUT CAST EASILY

BOTH FOR $42.50

See Your Dealer

STANLEY KUHLMAN MFG. CO.

2854 McCord Rd. Toledo, Ohio

A.M.A. ARCHIVES OF
SURGERY

Principles of Medical Writing

RAYMOND WHITEHEAD, D.Sc., M.D., Manchester, England

Foreword

In the Aug. 25, 1956, issue of The Lancet *Dr. Raymond Whitehead, reader in pathology, University of Manchester, had a special article on "English for Doctors." It was so interesting and seemed to be so valuable for all of us who are reading and writing for medical and surgical journals that he was asked if he would write a somewhat similar article for the* A. M. A. Archives of Surgery. *This he has done, and his paper on "Principles of Medical Writing" appears in this issue. I am sure that our readers will find it an article of real interest.*

Waltman Walters, M.D.

The physician can hardly escape writing something. If he is a teacher, the writing of scientific papers will be an important part of his work. Others may practice in silence for years; then comes the request for a presidential address, or some shorter piece, such as an obituary notice. Some kinds of writing are not meant for publication—for example, the thesis for a university degree and the report of the radiologist or pathologist. These and many other forms of medical writing call for a measure of literary skill. This may be gained by long practice, but the apprenticeship period can be shortened by study of the art of writing.

There are four roads to self-improvement in writing: (1) study of works on the subject, including the instructions given in each issue of many periodicals; (2) study of examples relevant to one's own particular problem; (3) criticism of one's manuscripts by colleagues, and (4) comparison of manuscript with proof, which reveals the professional skill of an editor. An author who takes the trouble to improve himself in these ways cannot fail to enhance his reputation and at the same time earn the thanks of his readers.

Received for publication March 4, 1957.

Reader in Pathology, University of Manchester.

General Principles

Brevity.—This is one of the greatest virtues in a medical writer. It means writing only what is essential to make one's point. It is achieved by (1) writing short articles, (2) avoiding repetition, (3) writing short sentences free from strings of subordinate clauses, and (4) using the shortest suitable words. Medical English today largely consists of anglicized Latin, which has many long words; there is no reason why these should continue to be used in preference to shorter, native English words.

There are two special reasons for writing briefly. The first is the heavy demands on a medical reader's time. A concisely written article will attract and hold even those who are not specially interested in the topic; a long-winded article will not be read to the end except by those who must read it as a matter of duty—and such readers will be left exhausted and displeased. The second reason for writing concisely is consideration

for the many readers whose mother tongue is not English; these readers should not be driven to the dictionary any oftener than is absolutely necessary.

Clarity.—This is attained by (1) using marks of punctuation in accordance with the sense, (2) avoiding ambiguous words and phrases, (3) avoiding disruption of the text by bulky data, (4) condensing data by using tables, and (5) omitting all nonessential details. For example, one should never write "the author believes," because "the author" may be the writer of these three words or an author he refers to. The text should not be broken by a series of similar case histories, protocols, tables, or other repetitive matter; instead, one typical example of each should be given, the information in the material withheld being concisely summarized.

The significant points in a series of case histories can often be summarized in a table. The impulse of most authors is to include too much detail. If detail is essential, it is better to present it in a few small tables than in a single large one. The best tables are so clear that the pattern of the entries is equivalent to a diagram. There is great scope for studied omission of nonsignificant detail in case reports; as Fishbein finely puts it, this "will make a clinical picture that will be as striking as a marble bas-relief."

Variety.—The old-fashioned paper consisted of pages of unbroken print—as monotonous as a desert or a cloudless sky. The eye and the mind both demand the relief of a varied landscape. This is provided by (1) headings; (2) small type for reviews at the start of a paper, methods, protocols, and case histories, and (3) illustrations, both pictures and diagrams, tables, and graphs. A paper can stand from three to six main headings, a few tables, and as many photographs as would (if placed together) fill one or two pages. If there are too many headings, or if paragraphs are too short, the text will have a fragmented appearance, and the reader will feel that he is being continually jolted; these two faults are easier to see and correct when the text is typed than when it is handwritten, because typed material is more compact.

Cooperativeness.—Multiple authorship is increasingly common, owing to the complexity of modern problems. The happiest collaborations are those between workers in different subjects—for example, surgeon and pathologist. Each is a principal in such an enterprise, and each learns much from the other. Papers by a surgeon alone, in which he simply incorporates the pathologist's report, are less interesting and valuable; so are papers by a pathologist who ignores the clinical aspects of his cases. When collaboration results in a series of papers, good will is created by an unvarying order of names; this is lost if the order is varied.

Courtesy.—Anyone who writes much cannot hope to avoid making mistakes—major or minor. A reader who discovers these should not write a paper solemnly exposing them; he should write to the author, who will usually be grateful if his correspondent will correct them in his next paper. When there is disagreement on an important scientific question, the parties should meet for discussion and so minimize or avoid public controversy; if public disagreement is unavoidable, it should be pursued with civility. Lastly, a word of praise never comes amiss. Advanced research is a lonely affair, and only a few workers can fully appreciate a specialized paper. Nothing is more welcome to an author than a kindly note from another worker.

Types of Medical Writing

Scientific Articles.—These include (1) reports of research, (2) case reports, and (3) reviews of literature. The structure of such articles is too familiar to need discussion here, but a few special points may be mentioned. The summary of an article ought to be suitable for reproduction by a journal of abstracts. At present, summaries often merely expand the title and give too

little fact. It would be best if abstract journals drew up a few specific instructions, which authors of articles could be required to follow. Reviews of literature should not be a series of juxtaposed abstracts but should be a critical discussion of selected themes, references to literature being related to these. The difference between an article and a thesis should be clearly understood. An article reports facts or conclusions in the briefest possible way; in contrast, a thesis is a demonstration of capacity and is therefore much more detailed, both introduction and discussion being much longer than in an article.

Essays.—The danger is in excessive use of metaphor in both title and text.

A Physician Looks at Medicine
Medicine: A Retrospect and a Prospect
Medicine at the Crossroads
Medicine in Our Time
Medicine in the Melting Pot
Medicine Is Not Enough
Medicine Marches On
Medicine Yesterday, Today and Tomorrow
Stands Medicine Where It Did?
The Changing Face of Medicine
Watchman, What of Medicine?
Whither Medicine?

Some titles give no information whatever.

Backward or Forward?
Closing the Ranks
Counting the Cost
Facing the Future
New Horizons
Unity of Purpose

Flowery titles herald flowery texts.

The subject (whatever it happens to be) is bedeviled—it is the Cinderella of medicine. The remedy lies in discussions at the highest level, where unimpeachable sources hobnob with well-informed quarters. By keeping one's ear to the ground, one learns whether to lower one's sights or to raise them in order to surpass the target. In medical education, it is debatable whether monolithic integration is more viable than broad-spectrum differentiation, and whether optimal teaching is vertical or horizontal. What is certain is that an inflationary spiral leads not to shining uplands (or even a plateau) but to the poppy-peppered marsh of oblivion; from this, extrication of the medical essayist is feasible only if aid be swiftly channelled by a posse of streamlined indexers. Prerequisites are pertinent data; these will bear fruit in the form of broadly-conceived and well-rounded relief programmes shaped to the special outlet of transportation. A major essential is selective underpinning of appropriations portfolios; bottlenecks must be liquidated, and personnel-flexibility could be maximized under the broad umbrella of a humane and forward-looking operations co-ordinating committee.

It is best to give an essay an accurately descriptive, matter-of-fact title. In the text, metaphor should be avoided altogether or used with great restraint.

Book Reviews.—There is no standard form, but a good review answers the following questions:

What is the scope of the book?
What is its quality?
Who could profitably read it?
Should individuals buy it?
Should libraries buy it?
Are there serious errors or omissions?
Are printing and binding satisfactory?
Is the price reasonable?

The least helpful review is an essay on the theme of the book without comment on the book itself. Poor books and books by cranks should be reviewed in some circumstances—for example, if there is danger of many readers wasting their money by buying copies. Whether reviews should be signed or not is controversial. The signed review has the advantage that the author of the book and the readers of the review can discount any bias—and the significance of a criticism depends very much on who makes it. Book reviewing is matched in difficulty only by abstracting; editorial advice to book reviewers would be helpful.

Biopsy Reports.—These should be both concise and helpful to the surgeon. Elaborate reports take too long to read. A histological description may be technically accurate but fail to indicate what the pathologist thinks the surgeon ought to do. In difficult cases, surgeon and pathologist should confer, preferably before the written report is issued. The same principles should be applied in the writing of radiological reports.

Bibliography

When a problem first arises, one naturally consults works ready to hand, such as text-

books or monographs; these give the current opinion on the subject. But books are seldom authorities; they are normally only digests of the original literature published in periodicals, and the amount of information given in books on any specific point is far too small to serve as the basis of an original paper. Books may also be useful for the references they give to original papers; but such references are only a small selection, representing the bookwriter's personal judgment. The writer of a paper or thesis is not entitled to rely on the opinion of a bookwriter; he must delve into the original literature himself and form his own opinion. Another defect of medical books is that from the investigator's viewpoint they are always out-of-date; this is true even on the day of publication, owing to the time taken by printing and binding; important papers may have come out since the book went to press.

After consulting books, one can look through the issues of the current volume of a journal, and then through the indexes of a few earlier volumes. If the topic is of general interest, there will be something about it—an article, editorial, or annotation—in one of the leading weeklies or similar general journals; if the subject is specialized, the appropriate specialist journals will be more helpful.

At this stage, a more systematic search for the literature becomes necessary. This is made with the help of various catalogues, indexes, and journals of abstracts, which are to be found in every medical library. Among the most important of these guides are the "Index-Catalogue of the Library of the Surgeon General's Office," the *Quarterly Cumulative Index Medicus*, and the *Current List of Medical Literature*. The use of such works is best learned in the library with the help of the librarian. There is some overlapping of the various guides, but this provides a useful check on the completeness of one's own list.

The medical librarian is the writer's best friend and should always be visited if possible. The writer can then explain his problem and get expert advice on the compilation of his list of papers. If the writer cannot visit a medical library, the library staff may be willing to compile the list of papers, but this is an unsatisfactory arrangement; however willing the library staff may be, they are not physicians and cannot judge the relevance of papers with the speed and accuracy of the writer himself. The preparation of a list of medical papers is strictly medical work.

When one is compiling a list of medical papers, it is best to begin with the most recent and work backward in time. As often as not, a paper published during the last couple of years will be found to give a full review of the subject, and perhaps make much of the older work obsolete. For this reason, the most recent papers should be read promptly on discovery, and not be left for reading until the list is complete. It may take the equivalent of a week's full-time work to compile a list of papers, and weeks or months may be needed to read through all the papers on one's list.

The writer should make notes on every paper read, not forgetting to head his notes with the full bibliographic details: author, initials, title of paper, journal, year, volume, and the pages on which the article begins and ends. On reading through his notes, the writer can quickly assess the value of the literature, choose the papers worth mentioning, and decide on the tack he will follow in his own article.

Illustration

Illustrations are one of the chief means of conveying medical knowledge. They have two great recommendations: They are a form of language that all can understand, and they save much verbal description. Text and illustrations should be closely coordinated—the descriptive part of a text can be largely a commentary on pictures. A medical author should know the scope and potentialities of illustration, including photography, drawing, and painting. Few writers

themselves practice these arts; it is best for most authors to discuss their problems of illustration with medical photographers and artists.

An author should cooperate closely with his illustrators and make sure that they understand what is wanted. It is wise for the author to witness the taking of photographs; this is particularly important when tissue sections are being photographed, since much experimenting with fields, filters, and exposures may be needed to get satisfactory results. Illustrations should be prepared with a specific journal in mind. If it prints photographs on plates, the size and number of the photographs should be so planned as to make the most economic use of space available; if illustrations are reproduced in the text, their number is less important. Only one illustration of one point or feature is permissible, but several features may be shown in a single illustration. Because of their high cost, the number of illustrations should be kept to the minimum necessary for elucidating the text.

The features to be shown in a photograph should be made as conspicuous as possible. For example, the important part of a histological section may be magnified to fill the camera field (or as much of it as gives sharp definition); alternatively, a print may be trimmed until only the main feature is left—there is no reason why the whole of a print should be reproduced. Photographs of patients should likewise as nearly as possible fill the plate; the background should contrast sharply with the color of the skin and be free from distractions, such as furniture and patterned flooring or wallpaper.

Photographs should be sent for publication in the form of glossy prints, which should not be mounted. No marks should be made by pen or pencil on the back or front of a photograph, and no clips or pins should be used for fastening; all these are apt to produce irreparable damage to the surface. This can be avoided by writing all necessary details on a piece of paper, which is afterward stuck on the back of the print. Any necessary marks for the front of the photograph should be made on a piece of transparent paper, afterward superimposed on the photograph, without clips or pins.

If a patient could be recognized from a photograph, the patient's consent is necessary for the publication of the photograph in a journal or elsewhere; neglect of this precaution may lead to an action at law. A published photograph or other illustration may not be further reproduced without the consent of the author and editor, journal, or book publisher; unauthorized reproduction would be a breach of copyright.

Statistics

Statistical methods have proved of great value in medical research and are likely to be applied more widely in future; the methods themselves are continually developing. For these reasons, a medical writer should have an appreciation of the aims, principles, and limitations of statistics. This does not mean that he should himself practice statistics; his attitude to statistics should be like that of the surgeon to radiology and pathology—in other words, he should understand the general nature of the subject and the meaning of the results it provides.

The raw material of statistics is usually a series of numbers—say, the weights of 500 mice. Inspection of the list of unclassified weights gives only a vague impression; to sharpen this, one must calculate the mean weight and some figure for the range or dispersion of the individual weights above and below the mean value. If the weights are divided into classes, and the frequency of weights in each class is noted, the distribution of weights may show a distinct pattern; this may be even clearer if the figures are plotted on graph paper.

If the ages of the mice are known, the relation between age and weight during the growth period can be found and expressed mathematically. If the mice formed two groups on different diets, any effect of diet on weight can be similarly expressed. All the information obtainable from all the available knowledge of the mice could be stated

in a few figures, although much arithmetic might be needed to get these. The first use of statistics is therefore to reduce the physical bulk of numerical data, to reveal any pattern in them, and to show any relation between the variables studied.

Many statistical methods can thus be applied to data obtained by unplanned work. Equally important is the help that statistics can give in planning. For example, statistics provides rules for taking samples of any variable one wants to study; in this way, bias that might vitiate the results is avoided. The main contribution of statistics in the field of design is the discovery that the interactions of many factors can be studied simultaneously in one complex experiment; this demolishes the old idea that all factors but one must be kept constant in an experiment.

Among the applications of statistical design are clinical trials, in which a form of treatment is studied on a prearranged plan by physicians in different hospitals. The future of scientific therapeutics lies in the use of such methods; the results will be more certain than they have been after older methods, and will be got with much less expenditure of time and labor. As the years go by, these new methods are likely to change the character of medical literature, and there may well be less and less inconclusive debate about various clinical procedures.

The ever-growing interest in statistics carries certain dangers. One is the use of statistical methods by workers without mathematical ability and training; this may lead to serious errors. It may also lead to expecting too much from statistics, which cannot extract any information not implicit in the data. Two points on the meaning of "statistically significant" should be clearly appreciated. First, if a difference is statistically significant, the fact does not mean that the worker's pet theory is correct; second, if a difference is not statistically significant, it is not necessarily due to chance—in other words, its "significance" may be real but not demonstrable owing to large sampling errors.

Foreign Languages

As the language of medicine, English is the heir of Latin. It is now so widely used that a knowledge of other languages is no longer essential to the medical writer. On all topics of importance, he will find some literature in English; if he gives up the impossible hope of compiling complete bibliographies, he has no need to go outside it. But the writer who knows only English must forgo important papers (or have them translated) and can never appreciate the distinctive approaches of different nations to medical problems. Perhaps the monoglot writer is a fiction, for knowledge of at least one foreign language is a universal mark of a good education. The foreign language learned at school or college will almost certainly be one of the most widely spoken European languages, all of which have important medical literatures.

The foreign languages most important to the general reader of medical literature are French, German, Italian, Portuguese, Russian, and Spanish; the study of any of these would be a good investment of time and effort. The relative value of the individual languages may vary with the branch of medicine, or even with the particular topic; in pathology, for example, the most useful foreign language is German. Medical periodicals appear in over thirty foreign languages; the reader of any of these could use his knowledge not only in his own work but also in the service of the profession as an abstracter, translator, or book reviewer.

A foreign language should be approached broadly, even if it is needed only for medical reading. Technical vocabulary is the least of the difficulties and can be quickly acquired by reading a medical textbook in the language; the student who does this will have little need of a dictionary. Far more important is a grasp of the nontechnical vocabulary; the troublesome words are the little ones that pop up continually—adverbs,

prepositions, and conjunctions; and, of course, one must know the essentials of the grammar. To study only "scientific" German is to study in blinkers—in fact, to miss the chief reward of language study, which is an intelligent insight into the character and modes of thought of the people who speak the language. Knowledge of these things is helpful in understanding any kind of writing, including scientific; and the best reader of scientific German (or any other language) is the man who has studied the language for its own sake.

The chief problem of the writer who wants to learn a language is to find time. The leisure of schooldays is a thing of the past, and language study must be fitted into a day already well filled with professional work. The writer may be able to attend classes in a university or elsewhere or to get private tuition; he could use the facilities offered by foreign cultural organizations, including summer schools in the foreign country. In all such cases he will get advice about textbooks from his instructors. More probably, he will not have time to attend any courses; his main difficulty will then be to find suitable textbooks.

The best textbook for the student working on his own is one assuming that the student has no other help. There are several well-known series of textbooks of this kind. One or two of these series are meant primarily for the tourist, who wants only the bare minimum of information; they do not provide an adequate basis for reading. Another series has a broader aim; each book gives a reasoned account of the language, often prefaced by a sketch of its history—a valuable aid to understanding. There are exercises with a key, which can be back-translated for further practice. Such a manual can be mastered in about six months, the essential condition for success being regular work—say half an hour daily. At the end, the student will have a clear insight into the language and some confidence in using it. For those who prefer to learn by listening, there are excellent language courses on gramophone records.

Summary

An author can improve his work by studying works on writing and by having his manuscripts criticized by colleagues. The best writing is brief, clear, and pleasantly varied by the wise use of headings, small type, and illustrations. The best work often results from collaboration between workers in different subjects. An author should be courteous and helpful to fellow workers.

The structure of scientific articles is well understood, but essays and their titles are apt to be too metaphorical, creating difficulties for indexers. Book reviews and summaries of articles could be more informative, and editorial advice on how to write these would be helpful. Biopsy and radiological reports should be brief but should make clear what action is indicated.

Skill in expression and in preparing manuscripts are the marks of the craftsman, but more is needed to make a good writer. Quality springs from a sound knowledge of bibliography and an appreciation of medical illustration and of statistics. Broader vision and sympathies result from ability to read foreign languages.

Department of Pathology, University of Manchester, York Place (11).

BIBLIOGRAPHY

Bett, W. R.: The Preparation and Writing of Medical Papers for Publication, London, Menley and James, Ltd., no date.

Cambridge University Press: Preparation of Manuscripts and Correction of Proofs, London, 1951. (This deals with books only, not articles.)

Collins, F. H.: Authors' and Printers' Dictionary, Ed. 9, London, Oxford University Press, 1946.

Fishbein, M.: Medical Writing: The Technic and the Art, Ed. 2, Philadelphia, The Blakiston Company, 1948.

Hart, H.: Rules for Compositors and Readers at the University Press, Oxford, Ed. 36, London, Oxford University Press, 1952.

Hill, A. B.: Principles of Medical Statistics, Ed. 6, London, The Lancet, Ltd., 1955.

Howie, J. W.: On Writing to be Read, Lancet 2:320-321 (Aug. 25) 1951.

Jordan, E. P., and Shepard, W. C.: Rx for Medical Writing, Philadelphia, London, W. B. Saunders Company, 1952.

Morton, L. T.: How to Use a Medical Library, Ed. 2, London, William Heinemann (Medical Books), Ltd., 1952.

Royal Society: General Notes on the Preparation of Scientific Papers, London, Cambridge University Press, 1950.

Trelease, S. F.: The Scientific Paper, Ed. 2, London, Baillière, Tindall & Cox, Ltd., 1951.

Whitehead, R.: Modern Languages in the Service of Medicine, Brit. M. J. 1:147-149 (Jan. 22) 1949.

Preparation of Theses for Higher Degrees, Lancet 2:323-326 (Aug. 25) 1951.

On Case-Reports, Lancet 2:475-478 (Sept. 5) 1953.

English for Doctors, Lancet 2:390-393 (Aug. 25) 1956.

Wilson, G.: The Role of the Medical Librarian, M. Press 227:456-460 (May 14) 1952. (An excellent introduction to library work for medical students and physicians. Reprints available from Mr. G. Wilson, Medical Library, The University, Manchester 13, England.)

Note for Language Students

Excellent manuals of self-instruction in languages are included in the "Teach Yourself" series of educational books published by the English Universities Press, Ltd., St. Paul's House, Warwick Sq., London, EC 4. Many European and some Oriental languages are now covered, and new languages are regularly added. Gramophone courses in many languages are obtainable from the Linguaphone Institute, 30 Rockefeller Plaza, New York 20, or 207-209 Regent St., London, W 1.

Experimental Observations on Delayed Rupture and Secondary Hemorrhage from the Spleen

GEORGE W. DAVIS, M.D.; H. WARNER WEBB, M.D., and JOHN M. HOWARD, M.D., Atlanta, Ga.

Delayed rupture of the spleen is defined as profuse intra-abdominal hemorrhage occurring 48 or more hours after blunt trauma to the spleen, the period during the initial 48 hours following injury being relatively symptom-free. In two reports, the incidence of splenic hemorrhage was 30% of all subcutaneous abdominal injuries in 1932 and 48% in 1939.[9] This was the most frequent intra-abdominal injury resulting from blunt trauma. The higher incidence of splenic trauma in 1939 may have stemmed from the increasing number and force of automobile accidents.

Immediate rupture of the spleen following blunt trauma occurs six times as frequently as does delayed rupture,[9] but, with one of every six splenic ruptures presenting as a delayed hemorrhage, the need for data concerning its pathogenesis becomes apparent. The only information at present is that based on clinical impressions, as no report of experimental observations has been found.

Experimental Method

Sixteen adult mongrel dogs were used in this experiment. The study was designed to traumatize the spleen so as to simulate subcutaneous injury, and then to follow the animal by clinical observation and reoperations in an effort to identify any delayed hemorrhage. A midline upper abdominal incision was used for the initial operation, and a left paramedian incision was used for secondary operations. Pentobarbital sodium was used intravenously for anesthesia.

Submitted for publication Feb. 20, 1957.

Joseph Brown Whitehead Professor of Surgery (Dr. Howard).

From Grady Memorial Hospital and Emory University School of Medicine.

Supported in part by a grant from the Department of Army (DA-49-007-MD-732).

Spleens were traumatized in two ways, in an effort to reproduce the types of anatomical defects seen in clinical surgery. Subcapsular and intrasplenic hematomas were created by traumatizing the spleen with the blunt surface of an abdominal retractor, using repeated, carefully placed, light blows until it was obvious that a hematoma was forming. The spleen was then replaced in the abdomen, to be inspected again one week later with respect to increase in size, rupture, bleeding, and adherence of various organs and omentum. Thereafter the dogs were followed for four to six weeks, after which the spleen was again surgically exposed. This injury was produced in 10 dogs.

The second type of trauma consisted of incising the spleen with a knife. The incision would frequently go through the entire spleen into the hilus, as is sometimes observed at operation or autopsy in patients whose spleen is fractured. The incision in the spleen was actively bleeding when replaced in the abdomen. No effort was made to obtain hemostasis in the spleens. Six dogs were studied in this manner.

Results

Splenic injury was well tolerated by the dogs. No animals died of splenic hemorrhage. One dog died immediately after operation of an overdose of anesthetic. Postmortem examination showed the spleen of this dog to be intact except for the presence of the subcapsular hematoma (Fig. 1).

In 10 dogs large hematomas, ranging from 2 to 10 or 15 cm. in diameter, were produced. Most of these were subcapsular. Three of the largest subcapsular hematomas ruptured spontaneously within one week. When they were electively reexamined, there was no active bleeding present—only old, dark, nonclotted blood around the spleen. In one of these animals, bright-red bleeding occurred from the site of rupture when the spleen was mobilized. When the spleen

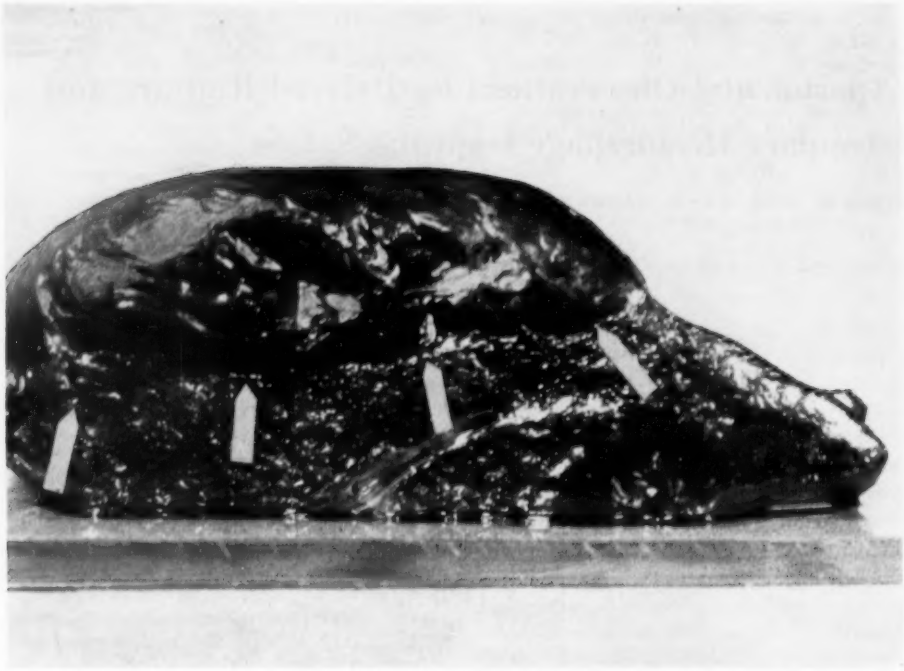


Fig. 1.—Subcapsular hematoma immediately following blunt trauma. The spleen has doubled in size, owing to the large hematoma indicated above by the arrows.

was replaced in the abdomen, it was bleeding actively, but the dog survived and at the third operation, one week later, the spleen was found to be surrounded by omentum. A soft, easily removable blood clot was present at the site of laceration. The subcapsular hematoma was still present, but a perisplenic hematoma had formed at a point where the hematoma had perforated the splenic capsule. The other hematomas increased in size during the first postoperative week. Around each, omentum was firmly adherent (Fig. 2). The injured splenic surface was often adherent also to the lateral abdominal wall.

The spleens which had been lacerated by through-and-through incisions showed perisplenic hematomas and evidence of repair of the cut surfaces. A soft clot was present over each laceration, and the spleen was easily fractured in the bordering areas by slight trauma. When the latter occurred, active bleeding from the splenic pulp again resulted. Similarly, when the adherent omentum was stripped from the injured spleen, oozing resulted.

One dog, subjected to blunt trauma to the spleen, had a simultaneous resection of his omentum. Upon reoperation, the spleen was adherent to the lateral abdominal wall in such a way as effectively to seal its injured surface.

Comment

In first describing the syndrome of delayed splenic rupture, McIndoe [4] classified splenic injury under three types: (1) minor superficial capsular rupture or slight splenic contusion; (2) intrasplenic hematoma or subcapsular hematoma without capsular rupture, and (3) capsular and parenchymal rupture with perisplenic hematoma. All three types of trauma were produced in these experiments, and each resulted in hemostasis for at least seven days.

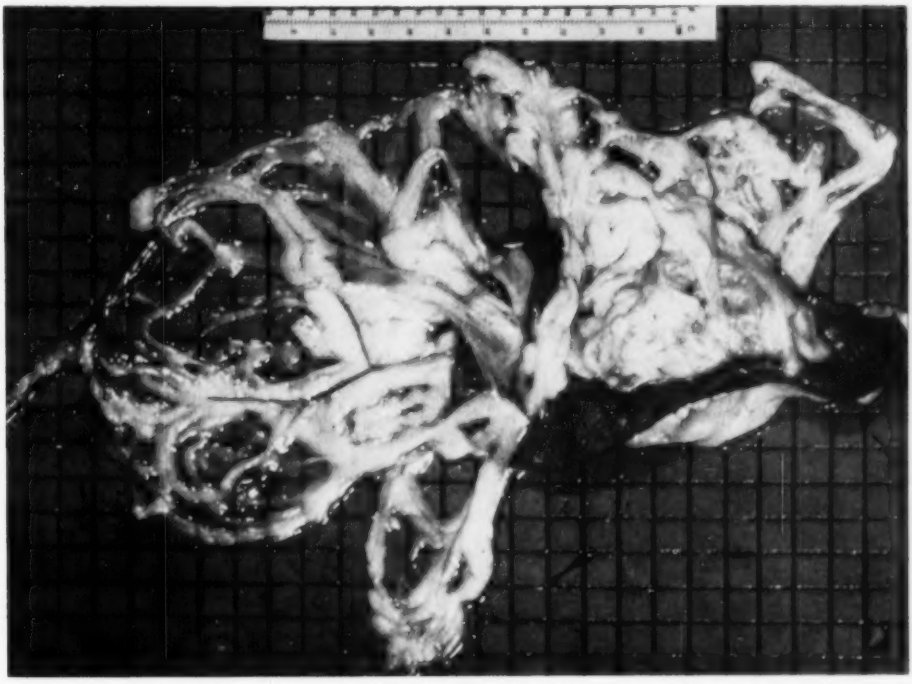


Fig. 2.—Omental adhesions around a spleen which had been injured by blunt trauma one week previously. These adhesions isolate the area of splenic injury and appear to minimize the severity of secondary bleeding. Slight tension on such an adhesion may tear it from the underlying hematoma and initiate secondary bleeding at any time during the early post-injury period.

McIndoe believed that laceration of the spleen occurring at the hilus led to immediate hemorrhage and was not involved in the syndrome of delayed rupture. In the current experiments the hilus was incised on several occasions without resulting in a fatal hemorrhage. This difference between clinical and experimental observations may be the result of the central abdominal position and mobility of the spleen in the dog, which permits numerous perisplenic adhesions.

The mechanisms which are used by nature to prevent immediate hemorrhage from all splenic lacerations were beautifully displayed in the dogs studied. The omentum and abdominal wall were the most effective tampons in walling off perisplenic hematomas; however, the stomach, colon, and diaphragm were involved to a less extent. In the experiment in which the spleen was lacerated and the omentum removed, the abdominal wall and organs in its vicinity effectively served as a tampon.

The pathology observed at the second and third operations suggested a mechanism of delayed hemorrhage from the spleen. Since the injured spleen was surrounded by blood clots, omentum, and other organs, it was necessary to lift away the surrounding clot in order to visualize the spleen. When this was done, bright-red blood escaped from the sites of injury. Very little effort was required to dislodge the tampon from around the spleen and produce active bleeding. In fact, only trivial force was necessary to further tear the spleen, extending the wound of the initial injury. It is therefore conceivable that, clinically, a minor secondary blow to the left side, even turning in bed or jarring the abdomen in quick movements, might dislodge a portion of the clot

from the spleen and result in profuse hemorrhage.

No dog was lost from immediate or delayed hemorrhage. If this observation is extrapolated to clinical experience, it is possible that many humans are leading normal, symptom-free lives, having previously received sufficient trauma to the abdomen to cause a small subcapsular hematoma or laceration of the spleen. Were this true, autopsy should demonstrate evidence of old splenic lacerations or hematomas in patients dying of unrelated cases. A study of 25,000 consecutive autopsies at the University of Minnesota revealed no evidence of healed splenic injuries.[8] This fact is strong evidence against the possibility that subclinical injury of the spleen is a frequent sequela of trauma.

Summary

Ten dogs received blunt trauma to their spleens, resulting in subcapsular and intrasplenic hematomas. These dogs were reexplored one week later, and each splenic hematoma was found to have increased in size. Omentum, intestine, stomach, and lateral abdominal wall were adherent to that surface of the spleen which overlay the hematoma. Three of the largest hematomas had spontaneously ruptured, causing no apparent ill effect to the dog. One of these began actively bleeding when examined at reoperation, but the dog survived and at a third laparotomy was found to have a very large perisplenic hematoma.*

Six of the dogs received incisions in their spleens simulating splenic fractures. Perisplenic hematomas formed, but no death resulted from this trauma. The site of the laceration was easily reopened by minimal secondary injuries.

These observations support the concept that delayed rupture may occur from superficial or deep lacerations of the spleen. Subcapsular hematomas continue to increase in size for an undetermined period of time. Rupture of the capsule may result from immediate pressure, ischemic necrosis, or tearing the capsule as adhesions are pulled away by secondary trauma. In animals in which the splenic capsule was initially lacerated, secondary hemorrhage would appear to result from disruption of the hematoma by the shifting of the adherent omentum, viscera, or other adherent surfaces.

69 Butler St., S. E. (3).

* Six dogs were killed nine months after injury. Only a splenic scar marked the site of injury.

REFERENCES

1. Bradley, T.: Delayed Rupture of the Spleen: Report of Case and Discussion of Mechanism, M. Ann. District of Columbia 14:103-107, 1945.

2. Bueermann, W. H.: The Latent Period and Delayed Hemorrhage Following Traumatic Rupture of the Spleen, U. S. Naval M. Bull. 41:73-93, 1943.

3. Helman, P.: Delayed Splenic Rupture, South African M. J. 29:748-750, 1955.

4. McIndoe, A. H.: Delayed Hemorrhage Following Traumatic Rupture of the Spleen, Brit. J. Surg. 20:249-268, 1932.

5. McLaughlin, E. F.: Secondary or Delayed Hemorrhage from a Ruptured Spleen, Am. J. Surg. 61:124-125, 1943.

6. Novak, E.: Large Single (Nonparasitic) Cysts of the Spleen, Surg. Gynec. & Obst. 45: 586-589, 1927.

7. Olander, G. A., and Reimann, A. F.: Post-Traumatic Intermittent Splenic Hemorrhage, Ann. Surg. 137:104-107, 1953.

8. Waugh, R. L., and Prior, J. A.: Traumatic Rupture of the Spleen with Delayed Hemorrhage, with Reference to Condition as Complication of Rib Fracture, Surgery 14:125-133, 1943.

9. Zabinski, E. J., and Harkins, H. N.: Delayed Splenic Rupture: A Clinical Syndrome Following Trauma, Arch. Surg. 46:186-213, 1943.

Renal Revascularization by Splenic Artery Implantation

An Experimental Study

H. CLINTON DAVIS, M.D., and IRWIN S. MORSE, M.D., Miami, Fla.

The experimental methods of kidney revascularization have focused upon (1) omentorenopexy,[1] (2) myorenopexy,[2] (3) enterorenopexy,[3] and (4) splenorenopexy.[4] The technique of Vineberg,[5] with direct arterial implantation of a systemic artery into the renal cortex, has not been explored to our knowledge.[6] The present study was undertaken to determine the adequacy of the Vineberg principle on the kidney, inasmuch as this organ is more easily studied than either the heart or the liver.[7] The ease with which the blood supply of the kidney can be controlled, and function studies performed, makes the kidney the organ of choice in evaluating the effectiveness of arterial implantations for collateral circulation.

Submitted for publication March 25, 1957.

Department of Surgery, University of Miami School of Medicine, and Veterans' Administration Hospital, Coral Gables, Fla.

Method

Large, healthy dogs were anesthetized with pentobarbital sodium (27 mg. per kilogram of weight). After exploration of the abdomen through a midline incision, the spleen was excised. The stump of the splenic artery was freed of the surrounding adventitial fat for a distance of 1 in., and bleeding from the lumen of the splenic artery was controlled with a bulldog clamp. A 1 in. tunnel was prepared in the cortex of the left kidney with a blunt hemostat, and the splenic artery was introduced into this channel with a 6-0 arterial silk traction suture through the open lip of the splenic artery (Fig. 1). The cut end of the splenic artery was anchored near the capsule of the kidney by the use of the traction suture and a short piece of rubber tubing; concomitantly, the renal artery was wrapped with cellophane to produce progressive local reaction, with narrowing of the renal artery lumen. Upon release of the bulldog clamp from the splenic artery implant, bleeding was controlled by continuous, gentle pressure with a gauze sponge for five minutes.

Fig. 1.—Technique of splenic artery implantation into the renal cortex.

At a second procedure, the right kidney was removed in two animals. In one instance the right

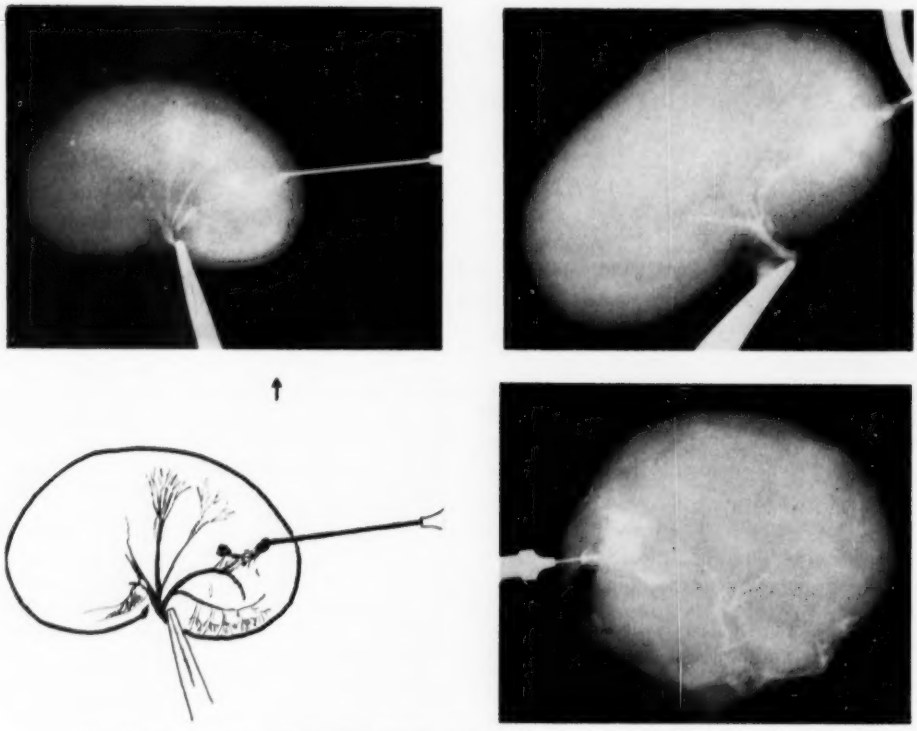


Fig. 2.—Iodopyracet (Diodrast) injections into the stump of the splenic artery implant. Of particular interest is the link with the renal arterial tree in each instance.

kidney was removed at the time of the initial surgery. To produce initial ischemia, division of a major branch of the left renal artery was carried out in one animal several weeks after the renal splenic artery implantation. Generous parenteral fluid and vitamin supportive therapy were given. Urinalyses and periodic blood urea nitrogen determinations were performed. Upon killing the animals (two to six months), the revascularized kidney was studied with methylene blue and iodopyracet (Diodrast) injections to determine the extent of the collateral circulation. The injection needle was tied in place with a fine cotton ligature, and injections were made with pressures exceeding normal arterial pressure. Detailed iodopyracet vascular patterns of the excised kidney were recorded on cardboard film cassettes.

Results

All five of the dogs who were operated upon survived the arterial implantation procedure. Urine studies in the postoperative period showed hematuria, reflecting the operative renal trauma. The animals lost weight but not out of proportion to that which would be anticipated with similar surgery. Most of the dogs quickly regained appetite but not their lost weight. Blood urea nitrogen studies showed consistent elevations after the right nephrectomy. Two animals died late in the follow-up period of intraperitoneal hemorrhage from staged division of left small renal arterial branches. Collaterals were evident in the autopsy specimens.

In each of the other dogs killed after two months, collateral circulation between the splenic artery and the renal arterial circulation was clearly demonstrable. Both methylene blue and iodopyracet injections through the splenic artery filled the renal arterial tree. The possibility of arteriovenous communications could not be excluded in the x-ray pictures and the gross dissections. In the killed dogs, there was

active bleeding from the proximal end of the splenic artery when it was severed. Collateral blood flow was collected from the severed end of the renal artery and vein in one animal which had had his splenic artery implantation six months previously. One and a half milliliters of blood was collected in a period of one minute. This kidney had not been rendered ischemic.

Attempts at producing narrowing of the renal artery with cellophane wrapping were unsuccessful. The best collateral circulation was demonstrated in the dog whose kidney was rendered ischemic by ligation of a major renal arterial branch with silk.

Comment

The observations of Vineberg[5] demonstrate that some collateral circulation in the myocardium can result from direct implantation of an adequate systemic artery. Tissue anoxia and different arterial pressures in the host tissue and in the implanted artery appear to influence the success of the collateral communications. Vineberg showed a 76% successful anastomosis rate when the internal mammary artery was implanted into ischemic heart muscle, but his sucessful implantation rate dropped to 46% when employing normal myocardium in the experimental animal.[5] In only one animal in our series was satisfactory renal ischemia produced. Likewise, the most satisfactory collateral circulation between the splenic artery implant and the renal vessels occurred in this dog. Although collateral circulatory vessels were demonstrated in each nonischemic kidney, the complete resistance to injections of iodopyracet and methylene blue suggested failure until the x-ray films were developed and a small amount of collateral circulation was found. In no instance was it possible to consider ligation of the complete renal arterial blood supply.

Effective kidney revascularization implies both adequate collateral blood flow and communication with the renal artery so that at least a part of the augmented circulation reaches the glomeruli. Furthermore, the collateral channels should remain patent over an extended period of time. Baronofsky and associates[3] showed that the collateral circulation in the enterorenopexy meets these criteria. After the injection of India ink through the collateral bed, the pigment was recovered in the glomeruli. Experience now suggests that initial partial ischemia should be attempted at the time of splenic artery implantation. Careful dissection of the hilar structures of the left kidney will often reveal an extra branch of the left renal artery for ligation purposes. Brief experience demonstrates that it is safe to ligate one of these arterial branches in continuity with nonabsorbable ligature material. Partial ischemia is produced, and a possible vascular accident is thus prevented. Reoperation and mobilization of the left kidney should be avoided for two to three weeks after the initial implantation because of the danger of pulling the splenic artery out of its renal cortex bed. The animals seem healthier when the right kidney is permitted to function during the time of recanalization, intima proliferation, and development of collateral vessels in the left kidney.

The splenic artery was found to be thickened but patent in every instance. Injection studies were most satisfactory when the vascular bed was irrigated first with isotonic saline to wash out old blood and clots. Despite the sensation of total obstruction to iodopyracet injection, collateral patterns were found on development of the films. Methylene blue was recovered from the renal artery at the hilus.

Volume flow studies on one dog after a one animal; however, a number of technical difficulties were found. The blood was collected into a small glass beaker from the hilar artery and vein. It was necessary to hold the left kidney, and any change in pressure on the organ altered the rate of flow. Furthermore, it was difficult to ascertain how much blood was escaping by digital pressure and how much was from the splenic artery collateral bed. Hypotension was evident. The role of vasospasm and retraction

of the severed vessels, and the role of clotting within the organ could not be appraised. Inability to maintain blood pressure gave added difficulty. An effort was made to free the kidney completely of surrounding adhesions before making the blood flow measurement.

The exact mechanism of recanalization and formation of collateral flow is poorly understood. Differential arterial pressures, proteolytic enzymes, and phagocytosis would appear to play a role. Proliferating endothelium from the open end of the splenic artery and that from the traumatized surface of the renal cortical bed would appear to meet. Tissue ischemia would seem to favor increased capillary permeability and vasodilation of already existing vessels in the area.

Summary

Observations on five dogs in which the splenic artery was implanted into the left renal cortex showed some splenorenal collateral circulation.

This collateral circulation was most effective in a kidney which has been rendered partially ischemic by ligation of a branch of the left renal artery.

Volume flow studies were attempted in six-month waiting period suggested that the amount of collateral flow was small in the nonischemic kidney.

1242 DuPont Building, Miami, Fla. (Dr. Davis).

220 Miracle Mile Coral Gables, Fla. (Dr. Morse).

REFERENCES

1. MacNider, W. de B., and Donnelly, G. L.: Value of Omentopexy in Establishing Adventitious Circulation in the Normal Kidney, Proc. Soc. Exper. Biol. & Med. 40:271-272, 1939.

2. Bruger, M., and Carter, R. F.: Nephro-Omentopexy and Nephromyopexy in the Treatment of Arterial Hypertension, Ann. Surg. 113: 381-391, 1941.

3. Katz, Y. J.; Hannon, D. W.; Alden, J. F., and Baronofsky, I. D.: Revascularization of the Kidney, Surgery 39:623-629, 1956.

4. Weeks, D. M.; Steiner, A., and Victor, J.: Splenorenopexy in Essential Hypertension, Surgery 19:515-521, 1946.

5. Vineberg, A.; Munro, D. D.; Cohen, H., and Buller, W.: Four Years' Clinical Experience with Internal Mammary Artery Implantation in the Treatment of Human Coronary Artery Including Additional Experimental Studies, J. Thoracic Surg. 29:1-36, 1955.

6. Vineberg, A.: Personal communication to the authors.

7. Davis, H. C., and Morse, I. S.: Segmental Liver Revascularization: An Experimental Study, A. M. A. Arch. Surg. 74:525-527, 1957.

Perforation of Stress Ulcers of the Esophagus Following Thermal Burns

Report of Two Patients

JOHN R. DERRICK, M.D.; ALBERT H. WILKINSON, M.D., and JOHN M. HOWARD, M.D., Atlanta, Ga.

Introduction

Perforation of the esophagus and rupture of the esophagus have usually been described as separate entities. By definition, perforation of the esophagus signifies an erosion of the wall of the esophagus, except when produced by trauma or by instrumentation. Rupture of the esophagus refers to a tear in an undiseased esophagus. Well-documented reports cite pure examples of each entity. The following two cases lend impetus to the concept [21] that a combination of the two factors, perforation and rupture, is present, the tenet being that ulceration of the mucosa destroys the strongest layer of the esophagus, predisposing it to rupture should the intraesophageal pressure be suddenly increased by vomiting.

Report of Cases

CASE 1.—A 16-year-old white youth was admitted to the emergency clinic of Grady Memorial Hospital at 2:30 a.m., Aug. 11, 1954. Thirty minutes prior to admission he had been hitchhiking. When a driver stopped his car to offer him a ride, another automobile crashed into the rear of the stopped car. Gasoline sprayed over the patient and was ignited by a cigarette. On admission, the patient had 90% third-degree body burns and was restless and in shock. Admission studies revealed the hemoglobin concentration to be 22.7 gm. per 100 cc. and the hematocrit 67 vol. %. Shortly after his admission to the ward, his respiration became impaired, and a cyanotic tinge of the conjunctiva was noted. Tracheostomy relieved the respiratory symptoms. In spite of the relief obtained from improved ventilation and sedation, he continued to be extremely restless and vomited material consisting of small particles of food, without gross evidence of blood. Five and one-half hours after admission, his respirations became very shallow and rapid. He died a few minutes later.

Necropsy revealed a large linear tear in the lower one-fourth of the esophagus on the left side. The mucosa surrounding the tear was ulcerated. The serosal surface of the esophagus was covered with gray exudate, and the left pleural space contained 700 cc. of grayish-brown fluid. Both lungs were deep red in color and appeared hemorrhagic on cut surface.

CASE 2.—An 11-year-old Negro girl was admitted to the emergency clinic of Grady Memorial Hospital at 12:30 p.m., Dec. 10, 1955. A few minutes prior to admission she had sustained third-degree burns of 95% of her body surface when her dress caught fire from an open gas heater. On arrival, she was in shock, with a pulse rate of 128 per minute. Only the plantar and dorsal surfaces of her feet were not burned. Intravenous administration of blood and saline was started. As soon as her vital signs stabilized, dressings were applied and she was transferred to the ward. Hematological studies revealed the hemoglobin concentration to be 23.4 gm. per 100 cc. Because of associated burns of the oral and pharyngeal mucous membranes, a tracheostomy was done, after which she remained somewhat restless but fairly cooperative. Five and one-half hours after admission she began to have persistent, severe vomiting and became increasingly restless and incoherent. Nine and one-half hours after admission she complained of pain in her chest; her respiration became rapid and shallow; she died 10 hours after admission.

Autopsy revealed the terminal portion of the esophagus to be hemorrhagic and eroded. Two longitudinal ulcers were present, one measuring 3×0.5 cm. and the other 2×0.5 cm., with perforation through the second ulcer, on the left side of the lower esophagus, into the mediastinum.

Submitted for publication Jan. 31, 1957.

From the Whitehead Department of Surgery, Emory University School of Medicine, and Grady Memorial Hospital.

Comment

In both patients, attention was directed toward the correction of the blood volume deficiency, which appears to be the most frequent cause of early death following thermal burns. The antemortem diagnosis of perforation of the esophagus was not made.

In 75%-85% of patients with nontraumatic perforation of the esophagus the correct diagnosis is not made prior to death.[18,21] According to Irving and Bunch,[13] 85% of the patients with spontaneous perforation of the esophagus die within 48 hours. To reduce this mortality, early diagnosis and treatment must be instituted. To accomplish this, it would almost appear that one would have to consider perforation or rupture of the esophagus in any patient who vomits in association with the alarm reaction.

The lower part of the esophagus has a predilection for perforation and/or rupture, as demonstrated by numerous studies based on sound experimental and clinical observations.[1,3,14] Associated with this anatomical weakness are the more nebulous factors of incoordinate vomiting,[15] ulceration, and esophagitis[17] in the lower esophagus.

The esophagus has no serosal covering and very little adjacent support except in the mid and upper portions. Its musculature is peculiar in that its upper third is striated muscle, the middle third is an intermingling of striated and smooth muscle, and the lower third is smooth muscle. Immediately above the esophagogastric junction, the muscle fibers fan out to form a broad coating to the stomach, thinning the musculature of the lower esophagus. The muscosa, the strongest layer of the esophagus, receives little support from the thin interlacing submucosa.

Mackler,[16] duplicating the work of Mackenzie[15] and Burt,[3] demonstrated the pressure required to rupture the esophagus and the site of predilection. The pressure required to rupture freshly removed specimens ranged from 4.5 to 7.4 lb. per square inch, with an average of 5 lb. These findings differ somewhat from those of Andrews,[1] who found the average disruptive pressure to be 7.5 lb.; however, the modes of experimentation of the two investigators were different. Mackler used the entire esophagus, whereas Andrews used only segments. Burt,[3] testing all parts of the gastrointestinal tract, found that the mucosa was invariably the last layer to rupture. He also found that in adults and children all parts of the gastrointestinal tract rupture at about the same pneumatic pressure, slightly higher pressures being required in children. Andrews[1] credited Senn with the observation that bowel which had been weakened by enteritis ruptured at only 1.5 lb. In all experiments such as these, the dominant factor in the perforation of the alimentary tract is the rapidity with which the intraluminal pressure is increased, rather than the degree of pressure per se.

Well-documented observations have been reported of rupture of the esophagus unassociated with intrinsic disease or ulceration.[13,15,18] It has been postulated that the mechanism of rupture in these instances is an incoordination of the vomiting mechanism.[15]

Vomiting is considered to be a series of well-coordinated reflexes, consisting of relaxation of the cardia and the cricopharyngeal sphincter, associated with elevation of the larynx and the hyoid. Concurrently, there are a powerful descent of the diaphragm and a convulsive contraction of the abdominal muscles. Mackler[16] suggests that free egress of the gastric contents may be impeded by an organic or a functional obstruction. The functional obstruction may be spasm of the esophagus[4] or incoordination of the vomiting complex. In either instance, marked intraluminal esophageal pressure may be developed, to be dissipated along the channel or channels of least resistance.

Ulceration of the esophagus may occur in association with a faulty esophagogastric sphincteric mechanism, which allows reflux of gastric contents,[18] or in association with

midbrain lesions,[5] or in association with the alarm reaction.[21] From a study of 1000 consecutive autopsies, Woldman [24] found that the incidence of acute ulceration was the same in the stomach and in the esophagus, and only one-half as frequent in the duodenum.

Friesen,[9] in an excellent review of the genesis of gastroduodenal ulcers following thermal burns, cited the Jefferson study, which reported a 3.8% incidence of ulcers of the gastrointestinal tract associated with burns. He was able to produce gastric ulcers in dogs as early as four hours after subjecting them to burns. Perhaps the most notable finding Friesen made was the constant association of gastrointestinal congestion in burned animals with ulcer formation, and he postulated that the tissue anoxia secondary to congestion predisposes the mucosa to ulceration without necessarily having hypersecretion or hyperacidity present. Other studies [11,12] demonstrated a decrease in the gastric secretion and acidity following trauma, a decrease which persisted in some patients for 48 hours or longer. On the other hand, Gray and his associates [10] studied the effect of the intramuscular administration of corticotropin to normal subjects. In every patient they noted an approximate 200% increase in the basal and nocturnal gastric secretions of acid and pepsin when the patient was studied after several days of corticotropin medication.

Weigel and his associates [23] reviewed 139 patients who has gastrointestinal ulceration complicating burns. Twenty-two of their more recent cases were reviewed in detail. Of 10 patients who had severe hemorrhage, the ulcer was located on the posterior aspect of the first portion of the duodenum in 8 patients; and on the anterior aspect of the first portion of the duodenum in 1 patient, and multiple ulcers were present in the stomach and esophagus in 1 patient. Of seven patients in whom perforation had occurred, perforation of the anterior aspect of the first portion of the duodenum occurred in six patients, perforation of the stomach in six patients, and perforation of the esophagus in three patients. Five of these patients had multiple perforations.

Spontaneous perforation of the esophagus has been reported primarily in association with central nervous system disease, pyloric obstruction, or chronic vomiting from any cause. Cushing confirmed the observation by von Rokitamsky [5] that a relationship exists between disease of the brain and ulceration of the gastrointestinal tract. Fincher and Swanson [8] reported three cases in which spontaneous perforation of the esophagus followed craniotomy. Rankin's [20] patient, a 4-year-old boy with 25% second-degree burns, died of a perforated esophagus two days after receiving the burn. Erskine and associates [7] reported spontaneous perforation of the esophagus in two patients with bulbar poliomyelitis, and they concluded that ulceration of the esophagus occurred as a result of regurgitation of gastric contents with the patient in the Trendelenburg position. In the patient reported by Boyd [2] perforation followed repeated vomiting secondary to complete pyloric obstruction. Layne's [14] patient had a nonobstructive duodenal ulcer.

One-half to three-fourths of the holding strength of the esophagus is lost if the mucosa is ulcerated or torn.[6] Erosion of the mucosa from any cause might, therefore, weaken the wall to such an extent as to predispose it to rupture after even so minor a mechanical stress as vomiting.

Summary

Severe thermal trauma, presumably by initiating the alarm reaction, may result in acute ulcerations of the esophagus within a matter of a few hours. Ulceration of the esophageal mucosa destroys the strongest layer of the esophagus and predisposes it to rupture at the relatively low pressures induced by vomiting.

Department of Surgery, Emory University School of Medicine.

REFERENCES

1. Andrews, E. W.: Pneumatic Rupture of Intestine, Surg. Gynec. & Obst. 12:63, 1911.

2. Boyd, D. P., and Eytinge, E. J.: Perforation of Esophagus: A Complication of Obstructing Duodenal Ulcer, Gastroenterology 17:103, 1951.

3. Burt, C. A. V.: Pneumatic Rupture of Intestinal Canal, Arch. Surg. 22:875, 1931.

4. Butin, J. W.; Olsen, A. M.; Moersch, H. J., and Code, C. F.: Study of Esophageal Pressures in Normal Persons and Patients with Cardiospasm, Gastroenterology 23:278, 1953.

5. Cushing, H.: Peptic Ulcers and the Interbrain, Surg. Gynec. & Obst. 55:1-34, 1932.

6. Derrick, J. R.: Unpublished data.

7. Erskine, F. A.; Mason, J. H., Jr., and McDade, H.: Perforation of Esophageal Ulcers in Bulbar Poliomyelitis, Am. J. Med. 8:239, 1950.

8. Fincher, E. F., and Swanson, H. S.: Esophageal Rupture Complicating Craniotomy: Symptom Complex and Proposed Surgical Treatment, Ann. Surg. 129:619, 1949.

9. Friesen, S. R.: The Genesis of Gastroduodenal Ulcers Following Burns: Experimental Study, Surgery 28:123, 1950.

10. Gray, S. J.; Benson, J. A.; Reifenstein, R. W., and Spiro, H. M.: Chronic Stress and Peptic Ulcers: Effect of Corticotropin (ACTH) and Cortisone on Gastric Secretion, J. A. M. A. 147:1529, 1951.

11. Hardy, J. D.: The Adrenal Cortex and Postoperative Gastrointestinal Secretions: Clinical Significance of These Effects, Surgery 29:517, 1951.

12. Howard, J. M.: Gastric and Salivary Secretions Following Injury, Ann. Surg. 141:342, 1955.

13. Irvin, C. W., and Bunch, G. H.: Spontaneous Rupture of Esophagus, Am. J. Med. 17:571, 1954.

14. Layne, J. A., and Hildebrand, E.: Rupture of Esophagus Following Severe Vomiting, Gastroenterology 13:170, 1949.

15. Mackenzie, M.: A Manual of Disease of the Throat and Nose, New York, Wm. Wood & Co., 1880, Sect. 4, p. 113.

16. Mackler, S. A.: Spontaneous Rupture of Esophagus, Surg. Gynec. & Obst. 95:345, 1952.

17. Mellins, H. Z.: Esophageal Ulcer in Infancy, Am. J. Roentgenol. 68:634, 1952.

18. Muendel, H. J., and Levison, W.: Spontaneous Rupture of Esophagus, A. M. A. Arch. Surg. 67:943, 1953.

19. Palmer, E. D.: Attempt to Localize the Normal Esophagogastric Junction, Radiology 60:825, 1953.

20. Rankin, L. M.: Perforation of Esophagus After Burn, Am. J. Surg. 67:134, 1945.

21. Kirby, C. K.: "Spontaneous" Rupture of the Esophagus, Am. J. M. Sc. 229:199, 1955.

22. Selye, H.: The Alarm Reaction and the Disease of Adaptation, Ann. Int. Med. 29:403, 1948.

23. Weigel, A. E.; Artz, C. P.; Reiss, E.; Davis, J. H., and Amspacher, W. H.: Gastrointestinal Ulcerations Complicating Burns, Surgery 34:826, 1953.

24. Woldman, E. E.: Acute Ulcers of Upper Gastrointestinal Tract, J. A. M. A. 149:984, 1952.

Intrahepatic Cholangiojejunostomy (Longmire Procedure) in Carcinoma of Intrahepatic Bile Ducts

JOHN L. KEELEY, M.D., and ARNE E. SCHAIRER, M.D., Chicago

A recent report [1] has emphasized the small number of cases of intrahepatic cholangiojejunostomy recorded since Longmire and Sanford [2] introduced this procedure in 1948. Its authors have summarized 28 cases, 19 procedures having been carried out for benign obstruction and 9 for malignant obstruction. We wish to report an additional instance of the use of this operation. At first a benign process was thought to be obliterating the common bile duct, but at autopsy, 11½ months later, primary adenocarcinoma of the intrahepatic bile ducts was shown to be the cause of obstruction. The operation completely relieved the jaundice. The cause of death was hemorrhage from esophageal varices.

Report of a Case

A 64-year-old widow was admitted to the hospital Jan. 3, 1954, because of intermittent distress in the upper part of the abdomen for 20 years. There was evidence of cholelithiasis. There was no jaundice. On Jan. 8 a cholecystectomy and incidental appendectomy were performed, without difficulty. The patient made an uneventful recovery and left the hospital on the 11th postoperative day. The pathologist reported chronic fibrous cholecystitis, cholelithiasis, and vermiform appendix.

The patient was admitted again on July 21, 1954, when she complained of jaundice of three weeks' duration, accompanied by pruritus, dark urine, light stools, and occasional bouts of nausea, vomiting, and pain referred to the right scapula. There was evidence of weight loss but not of anemia. The icteric index was 100 clinical units. Obstruction of the common duct, caused by either stones or stricture, was suspected. On July 26, the abdomen was opened through the old incision.

Submitted for publication Feb. 26, 1957.

From the Departments of Surgery, Stritch School of Medicine of Loyola University and South Shore Hospital.

Exploration in the region of the porta hepatis and through a duodenotomy failed to identify the common bile duct. Innumerable attempts to aspirate bile with a fine needle were unsuccessful in locating any intra- or extrahepatic ducts. After a three-hour search, Penrose drains were placed in the area in the hope that a biliary fistula might form. The incision was closed in layers.

The jaundice persisted after the operation, and no bile drained from the incision. After 18 days, further waiting for an external biliary fistula to form seemed obviously unjustified. An intrahepatic cholangiojejunostomy was recommended before deterioration of the patient's condition would further increase the risk of this procedure.

The third operation was done on Aug. 13. The abdomen was opened through a left subcostal incision. The left triangular ligament of the liver was divided, and the presenting portion of the left lobe of the liver was compressed by a series of interlocking suture ligatures of 1 chromic absorbable surgical suture U. S. P. A portion of the left lobe of the liver 10 cm. long and 5 cm. wide, and varying from 1 to 6 cm. in thickness was excised. Two orifices which proved to be bile ducts were exposed. They were about 4 mm. in diameter, but we thought that a considerable portion of the left lobe would have to be removed to reach segments of these ducts at a point where their diameters would be significantly larger. Reaching them would likewise necessitate the anastomotic procedures being performed at a less accessible level. Accordingly, the ducts as originally exposed were used for anastomosis.

Although the patient had lost considerable weight, the mesentery to the upper loops of jejunum was thick with firm fat, particularly at the base. The fat made accurate identification of the blood supply difficult. Therefore we brought an intact loop of jejunum through the mesocolon for the anastomosis (Fig. 1).

The serosal surface of the jejunum near the mesentery was sutured to the deeper edge of the cut surface of the liver. Some liver was excised about the ducts so that they would protrude from the hepatic surface. No. 8 urethral catheters were

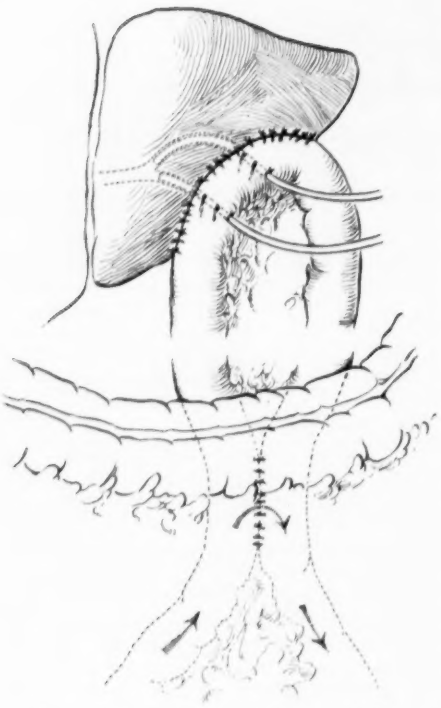


Fig. 1.—Use of two ducts of the left lobe of the liver for intrahepatic cholangiojejunostomy. The catheters, used temporarily as splints for the anastomotic sites, are perforated so that bile can enter the jejunal loop. A gastrointestinal study six months after operation showed that all the barium passed through the enteroenterostomy. None was carried to the region of the liver.

passed into the bile ducts, and bile promptly drained from both. Two small openings were made in the side of each catheter about a centimeter from the liver surface so that bile could escape into the jejunum when the anastomosis was completed. Multiple sutures were used to approximate the serosal surface of the jejunal loop to the raw surface of the liver to obliterate potential dead space.

A fine mosquito forceps was passed through both walls of the jejunum. The end of each catheter was grasped as it protruded from the bile duct, and the catheters were positioned as shown in Figure 1. Although mucosa-to-mucosa sutures were not used, the mucosal surfaces were brought together snugly with three silk sutures between the seromuscular layer and the liver placed as close as possible to the ducts and the catheters. The anastomosis was completed by sutures between the serosa and the capsule at the edge of the anterior surface of the liver. An enteroenterostomy was performed. The catheters were wrapped in omentum and brought out through a stab wound below the abdominal incision, which was closed about two Penrose drains leading from the operative field.

In the postoperative period, the temperature ranged from 100 to 102 F until the 16th day, when it reached 103 F. It remained there for several days until the patient was given chloramphenicol (Chloromycetin). Bile drained externally from the catheters in only small amounts. The icteric index decreased, and the stools became brown. The patient left the hospital on Oct. 2, with an icteric index of 15 clinical units.

She was admitted a third time on Oct. 8, 1954, for a three-day stay for a blood transfusion and withdrawal of both catheters, which had been clamped for six days.

Her fourth admission was on Dec. 24, 1954. She had been well in the interval but was admitted because of upper abdominal distress. The liver was 2 fingerbreadths below the costal margin. There was moderate anemia; the icteric index was 8 clinical units, and the nonprotein nitrogen 34 mg. per 100 cc. of blood. Roentgenographic studies of the stomach and duodenum showed no abnormality. Barium passed freely through the enteroenterostomy, but none was seen in the region of the intrahepatic cholangiojejunostomy. A bland diet and antispasmodic therapy for the gastrointestinal tract were prescribed.

The fifth, and final, admission was on July 28, 1955. The patient was bleeding from an esophageal varix. There was evidence of biliary cirrhosis and suppurative cholangitis. The white blood cell count was 49,000 per cubic millimeter. Blood cultures were reported as negative after six days of incubation. On the day after admission, a massive hemorrhage, indicated by profuse bloody diarrhea, occurred. The patient died on July 31, 1955, 11½ months after the intrahepatic cholangiojejunostomy. She had been free from jaundice during this period and had been comfortable until her last month of life.

Autopsy disclosed esophageal varices with evidence of recent hemorrhage, subpleural miliary metastatic adenocarcinoma of the lungs, and thrombosis of the portal vein. There were many small abscesses scattered throughout the right lobe and a large one in the central part of the right lobe of the liver. A firm gray tumor, about 5 cm. in diameter, was found in the hilar region; it obstructed the common, right, and left hepatic ducts.

The site of the hepatojejunal anastomosis was intact. By means of a cannula introduced into one of the ducts of the left lobe used in making the anastomosis, the ductal system of the left lobe was demonstrated (Fig. 2). The bile ducts did

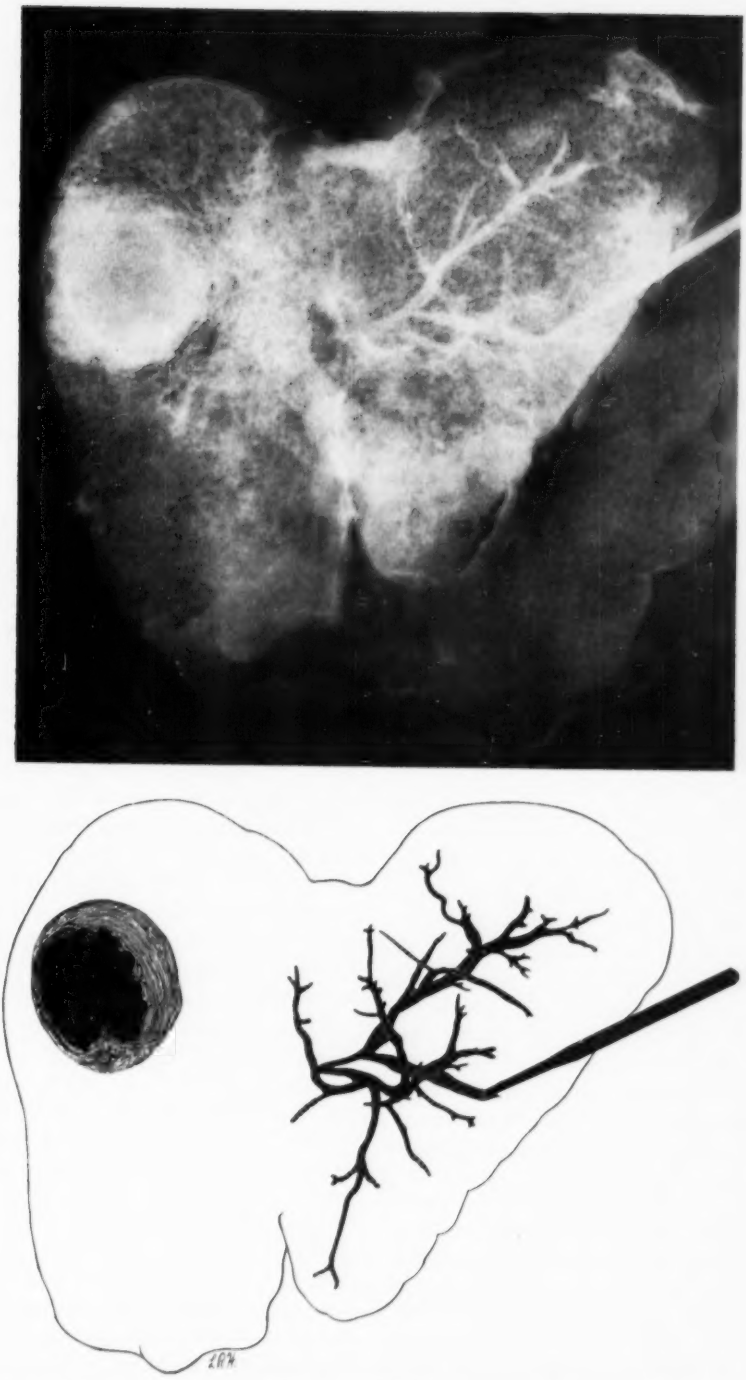


Fig. 2.—Injection study of the liver as recorded by roentgenogram and a diagram made from it. The ducts of the left lobe were patent, not dilated, and appear to have been effectively drained by the cholangiojejunostomy. The large abscess in the right lobe is also shown.

not appear to be dilated. They formed a pattern closely resembling the normal ones found in an injection study by Healey.[8] The communication between the right and left hepatic ducts, normally the only connection of significance, was obstructed by the tumor. The growth also obstructed the common hepatic duct. The tumor proved to be a primary adenocarcinoma of the bile ducts.

Comment

Studies of the distribution, patency, and effects of obstruction of the bile ducts are significant in considering the potential value of the Longmire procedure. Except for some minor communications in the caudal lobe, the right and left main hepatic ducts have no connections until they join in the hilar region of the liver to form the common hepatic duct. That is proved by demonstration of the intrahepatic ductal system through injection of contrast media and roentgenograms, as well as latex casts.[3,4] In seven patients[5-7] cholangiograms were made during or after completion of intrahepatic cholangiojejunostomy. The ductal systems of both lobes were drained by the procedure in all of the patients because of the connection of the right and left hepatic ducts where they form the common hepatic duct.

However, one need not drain the bile ducts of both lobes of the liver to relieve obstructive jaundice. Effective drainage of only the left lobe is sufficient, as shown by tests of liver function and by disappearance of jaundice. Evidence for this statement appears in the reports of patients in whom only the left lobe of the liver was drained by an intrahepatic cholangiojejunostomy (our patient and one reported by Waddell and Burbank[8]). It also appears in reports of patients with benign stricture of the common duct in whom only one hepatic duct, either right or left, found at exploration in the region of the porta hepatis was used successfully in biliary enteric anastomoses.[9-11] Although the situation is not completely comparable, the function of the left lobe of the liver has proved to be adequate in patients whose right lobe has been resected for tumor.[12-14]

Obstructing all but one-seventh of the biliary drainage apparatus causes no rise in the icteric index of dogs.[15] A transient rise in alkaline phosphatase, directly proportional to the functional ability of the obstructed hepatic segments, occurs but later falls as the obstructed parenchyma atrophies.[16]

Intrahepatic cholangiojejunostomy is indicated in patients whose bile ducts are not accessible in the porta hepatis. An exception is that group of patients with congenital biliary atresia, as it has been amply demonstrated that if their extrahepatic atresia is complete, the intrahepatic bile ducts are also atretic.[2,17]

Lahey[18] said that if there is enough common hepatic duct to provide communication between the right and left hepatic ducts, it is sufficient to permit a hepatojejunostomy, with sacrifice of only the amount of liver tissue which must be excised to expose the common hepatic duct in the porta hepatis. Apparently all surgeons do not concur in this conclusion, for seven of the reported patients treated by the Longmire procedure have had communications between the right and left hepatic ducts, as shown by cholangiograms. In many other patients, the surgeon believed both lobes were drained by the intrahepatic cholangiojejunostomy utilizing the ducts of the left lobe. That belief, while not proved by graphic studies, was based on the rapid decrease in jaundice and in the size of both lobes of the liver.

One may attempt to evaluate the potential value of the Longmire procedure on the basis of the cause of the biliary obstruction and the patency of the intrahepatic ductal system. For example, scar tissue obliteration of the common hepatic duct may not progress to occlude the junction of the right and left hepatic ducts, or may do so very slowly.

However, neoplasma may first obstruct the common hepatic duct and by continued growth later obstruct the junction of the right and left hepatic ducts. Thus, in either benign or malignant obstruction both lobes of the liver may be adequately drained by

the Longmire procedure initially, but progress of the original pathologic process may obstruct the junction of the right and left hepatic ducts. Atrophy, and in some cases infection, in the obstructed lobe follows; the outlook will then depend on the functional capacity of the adequately drained lobe.

Massie[5] suggested a preliminary operative cholangiogram at the time of the Longmire procedure so that a suitable duct might be chosen with sacrifice of the least amount of liver tissue. This avoids any unnecessary decrease in the amount of tissue in the left lobe, which would be the only functioning liver should the connection between the right and left lobes become obstructed.

Although there appears to be no report of a bilateral intrahepatic cholangiojejunostomy, Longmire[6] has suggested its possibility. He considered doing the anastomosis to drain the right lobe of the liver in a patient whose jaundice persisted after the left lobe had been drained. However, the jaundice was shown to be due to hepatic damage rather than to obstruction of the duct system of the right lobe, so that further surgical operation was not done.

Fibrotic obstruction of the extrahepatic biliary system is the most encouraging indication for intrahepatic cholangiojejunostomy. In the recent summary by Longmire and Lippman,[1] the results were best in patients with that condition. These authors found that two-thirds of the patients operated upon because of benign stricture were presumably alive at the time of their report. The patients had been observed for periods ranging from five months to five years. Eight had survived their operation longer than one year. Six died after periods of 12 days; 3, 13, and 30 months, and 4 and 5 years.

In nine patients the operation was done because of neoplastic obstruction. They survived from 5 weeks to 13 months. Their average survival time was 13 weeks. Progress of the disease by additional ductal obstruction or diffuse parenchymal involvement of the liver accounted for the much shorter survival time in patients with malignant disease.

A common complication of anastomoses between the biliary and the alimentary tract is ascending cholangitis. It is now recognized as being more commonly due to stricture and stasis than to reflux of material from the alimentary tract through the anastomosis.[9,10,19] The use of a defunctionalized loop of jejunum has been recommended to keep jejunal contents away from the region of the anastomosis and thus to avoid one source of ascending biliary infection.

In their original report, Longmire and Sanford[2] described the use of a loop of jejunum in performing intrahepatic cholangiojejunostomy. Although they recommended an enteroenterostomy in conjunction with use of the jejunal loop, they were prevented from following this recommendation in their first adult patient by the inadvertent selection of a short jejunal loop. Despite this omission, their patient was well for 22 months, after which "recurrent biliary difficulties" appeared. Thirty months after the first operation, surgical exploration, which the patient did not survive, disclosed stricture of the intrahepatic cholangiojejunostomy. The stricture appeared to be more important in the etiology of the "biliary difficulties" than the omission of the enteroenterostomy. Nevertheless, in subsequent reports Longmire has recommended the Roux en Y anastomosis.

Lippman and Longmire[6] described the case of a 45-year-old woman who came to them 14 months after an intrahepatic cholangiojejunostomy had been performed by another surgeon. A loop of jejunum without enteroenterostomy had been used for the anastomosis. The patient had jaundice, weight loss, hepatomegaly, and edema. She refused further surgical intervention. She returned one year later still jaundiced but willing to undergo a surgical operation. An upper gastrointestinal series showed esophageal varices. Sufficient barium passed through the intrahepatic cholangiojejunos-

tomy to outline the bile passages of both lobes. Since no obstruction was shown, the basis of her complaints was considered to be biliary cirrhosis and limited hepatic reserve as a result of the original biliary obstruction. The ease with which barium entered the biliary tract in this patient emphasizes, according to the authors, the necessity of using a defunctionalized jejunal loop. However, this patient lived four years after intrahepatic cholangiojejunostomy. The jaundice during this period was due to hepatic damage and not to either obstruction of the biliary tract or ascending cholangitis.

A jejunal loop with enteroenterostomy was used in the intrahepatic cholangiojejunostomy in our patient and in cases reported by Sanders,[20] Massie,[5] and Waddell and Burbank.[8] Sanders' patient, who had a benign stricture, was greatly improved during the 22 months of observation. Massie's patient also had a benign stricture. During the five-month follow-up period, one episode of cholangitis with jaundice and acholic stools occurred. Recovery followed. In the patient of Waddell and Burbank, undifferentiated adenocarcinoma originating in the bile duct or gallbladder obstructed the region of the porta hepatis. The jaundice subsided completely three months after the operation, but bouts of cholangitis persisted. A gastroenterostomy was necessary six and a half months after the hepatojejunal anastomosis because of duodenal obstruction. Two months later the stools became acholic. The patient died after a four-month period of deterioration, and 13 months after the intrahepatic cholangiojejunostomy. Autopsy showed that the tumor obstructed the common, right, and left hepatic ducts.

Prolonged biliary obstruction leads to biliary cirrhosis, which, in turn, may cause portal obstruction and hypertension. Bleeding from the collateral circulation may be troublesome or fatal. It may be spontaneous from esophageal varices, or it may be precipitated by attempts to repair a common-duct stricture. Cole, Ireneus, and Reynolds,[21] in discussing blood loss during repair of common-duct strictures, said that the large blood losses are due to portal hypertension, although an occasional patient may have a clotting defect. Twenty-nine of their 122 patients with common-duct stricture had portal hypertension. Four of the twenty-nine died of bleeding esophageal varices or uncontrollable hemorrhage when common-duct repair was attempted. Our patient died of esophageal bleeding 11½ months after the cholangiojejunostomy. One patient reported by Longmire died of the same cause 12 days after hepatoenteric anastomosis.

The importance of portal hypertension in patients with biliary cirrhosis is emphasized by the belief of Cole, Ireneus, and Reynolds that splenorenal shunt should be done as a preliminary procedure to the operation designed to relieve biliary obstruction.

Summary

A 64-year-old woman became jaundiced six months after cholecystectomy for gallstones. At exploration no common duct could be found. Three weeks later a Longmire procedure was done because of the inaccessible intrahepatic obstruction at the porta hepatis. The jaundice disappeared and did not return. The patient was reasonably comfortable but had transient bouts of chills and fever. She died 11½ months after the Longmire procedure as a result of hemorrhage from esophageal varices.

Autopsy disclosed that primary adenocarcinoma of the bile ducts obstructed the common, right, and left hepatic bile ducts. There were several small abscesses and a large one in the right lobe of the liver. The left lobe of the liver was drained adequately by the cholangiojejunostomy. The operation was considered to have been very helpful in the management of this patient's problem. The survival time was much longer than the average in patients with obstruction due to neoplasm.

The operation of intrahepatic cholangiojejunostomy is discussed in relation to the hepatic ductal system, etiology, and effects

of obstruction, and the results of cases reported to date.

Mercy Hospital, 2537 S. Prairie Ave. (16).

REFERENCES

1. Longmire, W. P., Jr., and Lippman, H. N.: Intrahepatic Cholangiojejunostomy—An Operation for Biliary Obstruction, S. Clin. North America 36:849-863, 1956.

2. Longmire, W. P., Jr., and Sanford, M. C.: Intrahepatic Cholangiojejunostomy with Partial Hepatectomy for Biliary Obstruction, Surgery 24:264-276, 1948.

3. Healey, J. E., Jr., and Schroy, P. C.: Anatomy of the Bile Ducts Within the Human Liver: Analysis of the Prevailing Pattern of Branchings and Major Variations of Biliary Ducts, A. M. A. Arch. Surg. 66:599-616, 1953.

4. Sloan, R., cited by Longmire and Sanford,[2] p. 273.

5. Massie, F. M.: The Longmire Operation for Common Duct Obstruction, Ann. Surg. 131:838-845, 1950.

6. Lippman, H. N., and Longmire, W. P., Jr.: Intrahepatic Cholangiojejunostomy for Biliary Obstruction, Surg. Gynec. & Obst. 98:363-372, 1954.

7. Baron, P. J., and Yamashita, T.: Intrahepatic Cholangiojejunostomy, Surgery 36:992-996, 1954.

8. Waddell, W. R., and Burbank, C. B.: Cholangiojejunostomy (Longmire Operation) for Relief of Biliary Obstruction Due to Carcinoma, New England J. Med. 247:929-932, 1952.

9. Cole, W. H., in discussion on Walters[10] and Longmire and Sanford.[22]

10. Cattell, R. B., in discussion on Walters[10] and Longmire and Sanford.[22]

11. Lahey, F. H.: Further Experiences with Injured Bile Ducts: New Method of Repair, New England J. Med. 240:161-168, 1949.

12. Lorimer, W. S., Jr.: Right Hepatolobectomy for Primary Mesenchymoma of the Liver, Ann. Surg. 141:246-250, 1955.

13. Pack, G. T.; Miller, T. R., and Brasfield, R. D.: Total Right Hepatic Lobectomy for Cancer of the Gallbladder, Ann. Surg. 142:6-16, 1956.

14. Pack, G. T.: The Epiphenomena of Total Right Hepatic Lobectomy, Surgery 40:611-614, 1956.

15. Markowitz, J.: Textbook of Experimental Surgery, Baltimore, William Wood & Company, 1937.

16. Schiffmann, A., and Winkelman, L.: Influence of the Liver on Serum Phosphates, Arch. Int. Med. 63:919-929, 1939.

17. Gross, R. E.: The Surgery of Infancy and Childhood: Its Principles and Techniques, Philadelphia, W. B. Saunders Company, 1953, pp. 511-523.

18. Lahey, F. H., in discussion on Massie.[5]

19. Walters, W.: Physiologic Studies in Cases of Stricture of Common Bile Duct, Ann. Surg. 130:448-454, 1949.

20. Sanders, R. L.: Hemihepatectomy with Hepaticojejunostomy for Irreparable Defects of the Bile Ducts, Arch. Surg. 58:752-761, 1949.

21. Cole, W. H.; Ireneus, C., and Reynolds, J. T.: Strictures of the Common Bile Duct: Studies of 122 Cases, Ann. Surg. 142:537-551, 1955.

22. Longmire, W. P., Jr., and Sanford, M. C.: Intrahepatic Cholangiojejunostomy for Biliary Obstruction—Further Studies, Report of 4 Cases, Ann. Surg. 130:455-465, 1949.

Gastroschisis

Report of a Case

WILLIAM B. KIESEWETTER, M.D., Pittsburgh

As one surveys the literature on the subject of gastroschisis, one is impressed by the confusion of thought which is occasioned by this term. There are those who use it to embrace all forms of anterior abdominal-wall maldevelopment and herniation.[1] There are others who use it to describe what Gross and Blodgett[2] have termed omphalocele. It has more recently been used by Moore and Stokes[3] to delineate a hernial abnormality of the anterior abdominal wall that occurs in the extraumbilical position. This use of the term is part of their classification of anterior abdominal wall abnormalities into three groups: (1) omphalocele, an umbilical cord abnormality; (2) intussusception through the omphalomesenteric duct, an omphalomesenteric duct abnormality; (3) gastroschisis, an extraumbilical abdominal wall abnormality. Gastroschisis is a Greek word meaning "belly cleft" and could, therefore, apply to any one of these abnormalities of embryonic development that lead to eventration or herniation through the anterior abdominal wall. The Moore and Stokes classification appeals to me, and therefore the abnormality in the case to be reported has been termed gastroschisis.

Embryology

There have been many theories put forth as to the embryologic course of events that leads to gastroschisis,[4,5] none of which seems completely to explain all varieties that have been noted in the literature. It is interesting to note that this condition occurs in lower animals as well as in the human subject, since it has been seen with comparative frequency in such animals as the pig, kitten, and lamb. Perhaps it can be most simply stated that there is some abnormality of the somites that form the anterior abdominal wall which allows for faulty development of a portion of the wall, resulting in a herniation through this defect. As has been indicated above, such a herniation occurs outside the umbilical area, and the umbilical-cord development itself is normal. Not infrequently, there is complete absence of a peritoneal sac encompassing a gastroschisis, as opposed to the presence of such a sac in an omphalocele. In reported cases of gastroschisis, the absence of a sac results in marked enlargement and thickening of the intestine, as well as firm matting together of bowel loops. The degree of compromise of blood supply depends upon the size of the defect in the abdominal wall through which the herniated viscera have come. This evisceration apparently takes place early in the embryonic development. Because of the lack of presence of the viscera in the abdominal cavity itself, there develops a great disparity between the size of the viscera and the size of the cavity.

Two cases of gastroschisis have been reported[6,7] since Moore and Stokes[3] added their two cases to the previous five in the literature. This makes a total of nine cases in children who were born alive with this condition, with two successful surgical corrections. The 10th case follows.

Submitted for publication Feb. 4, 1957.

Associate Professor of Surgery, University of Pittsburgh School of Medicine; Surgeon-in-Chief, Children's Hospital of Pittsburgh.

From the Department of Surgery, University of Pittsburgh School of Medicine and Surgical Clinic of the Children's Hospital of Pittsburgh.

Fig. 1.—Gangrenous intestine extruding through right rectus muscle defect. The umbilicus is not shown but was normal.

Fig. 2.—Resected specimen—part of jejunum, all of ileum, and ascending colon. Small mass at upper left is small abdominal wall defect that allowed intestinal extrusion and whose constriction then produced gangrene.

Report of Case

Baby boy Q was born by spontaneous delivery, after a normal pregnancy, on July 26, 1956. The child's delivery was three weeks before the expected date. The first physician who saw the patient recognized this case as one of a gross abnormality, for there was protruding from an aperture to the right side of the umbilicus a mass of black, gangrenous intestine. Immediate transfer was made to the Children's Hospital of Pittsburgh, at the age of 2 hours. The child seemed to be quite normal in its reaction and appearance except for an opening in the right rectus muscle area, which appeared to be 1 to 1.5 cm. in diameter. A mass of black, intestinal coils (Fig. 1) protruded through this aperture. There was no sac overlying this mass. The child seemed to be in no distress because of this defect and had shown no tendency toward vomiting. Abdominal exploration was indicated and carried out at the age of 4 hours. A circumferential incision was made at the base of the mass; and, upon opening the abdomen, it became apparent that the upper jejunum ended at the narrow orifice and that the opposite end of the blackened mass was the proximal transverse colon. The black bowel was excised (Fig. 2); the narrow orifice through the anterior abdominal wall was removed (Fig. 2), and a jejunotransversecolostomy was accomplished.

This child's postoperative course was a quite remarkable one, inasmuch as he began to eat within 48 hours after operation, and the number of stools was not excessive, although maintenance of weight was not possible until the introduction of intravenous fat in the form of Lipomul * on Aug. 19. The terminal series of events began on Aug. 26, when some skin abscesses developed over the lower extremities. Staphylococcus albus was cultured from them, and on Sept. 6 the blood culture was positive for the same organism. The child's course was then quite rapidly downhill; the stooling became uncontrollable, even on a regimen of nothing by mouth, and he died Sept. 11, of

* Lipomul (The Upjohn Company) is a 40% emulsion of peanut oil with 10% dextrose, 2% purified soybean phosphatide, and 0.02% synthetic emulsifier (alkylarylpolyether alcohol).

Clinical Course in Case of Gastroschisis in a Newborn Infant

Date	Weight	No. of Stools	Sodium	Chloride	Potassium	CO_2	Comment
1956	Lb. Oz.						
7/26	4 14						
7/28			139	97.4	6.4	20.5	
8/1	4 3	8	147	109.5	5.0	19.8	Nutramigen * started; folic acid 5 mg. b.i.d. started
8/8	3 13	6					
8/15	3 8	5					
8/19							Lipomul † 4 cc. every 2 hr. I.V. begun
8/22	4	5					
8/26							Leg abscesses; S. albus; Lipomul 4 cc. q.2h. by mouth
8/29	3 15½	10					
9/5	3 12	13					
9/6							Generalized sepsis with blood culture positive for S. albus
9/11	3 1	20	128	100.1	3.4	13.3	

* A carbohydrate-amino acid mixture.
† A 40% emulsion of peanut oil in dextrose, 2% soybean phosphatide, and 0.2% synthetic emulsifier.

inanition and septicemia. The nutritional and chemical course is summarized in the Table.

Comment

This case is of interest from two standpoints. First, the anomaly is an unusual congenital one that has not been recorded very often in a live-born child. This child presented something that the other recorded cases did not—strangulation of the extruded intestines, due to the narrowing of the abdominal wall defect. One would seem forced to conclude that the evisceration, which took place in utero, was composed of the major portion of the intestinal tract and the defect in the abdominal wall then went on to almost complete closure; in so doing, it brought about the strangulation of the extruded intestines. This was a very unfortunate series of events in this child, because virtually all the small intestine and a good portion of the large intestine were gangrenous and had to be resected. Anatomically, the amount of extruded intestines, had they been viable, would have been difficult to replace in the small abdominal cavity. However, it might have been possible to do so, and, if not, one could have covered them with skin, as outlined by Gross[8] in the treatment of large omphaloceles, with secondary ventral herniorrhaphy at a later date.

The second point of interest in this case is the surprising postoperative survival, considering the minimal amount of intestinal surface the child had for absorption. We noted that the administration of intravenous Lipomul seemed definitely to slow down the weight loss and actually to produce a weight increase for a time. We gave the Lipomul by mouth for about 10 days after its intravenous efficacy became apparent, but this was not utilized in the same way, as the child lost weight during this time. Feedings of a carbohydrate-amino acid mixture (Nutramigen) were used throughout the convalescence with the thought that this hydrolyzed protein mixture would have a greater opportunity to pass the intestinal barrier than any other form of feeding. Several suggestions have been made for the handling of the nutritional problems in a child who has large deficits in the small intestine. Gyorgy[9] feels that breast milk is the most easily absorbed food and recommends it in such cases. Cresson and Pilling[10] had dramatic results from extremely high caloric feedings in two successful cases of infants with massive resections of the small intestine. We have had some experience with breast milk in three such cases and have not been greatly impressed with the nutritional results of its administration. We have had no experience with the method of feeding suggested by Cresson and Pilling.

Conclusion

A case of gastroschisis is reported with complete strangulation of the intestine from high jejunum to midtransverse colon. The survival of this child for six and one-half weeks and the dietary problems involved are outlined.

Children's Hospital of Pittsburgh, 125 De Sota St. (13).

REFERENCES

1. Johns, F. S.: Congenital Defect in the Abdominal Wall in the New Born (Gastroschisis), Ann. Surg. 123:886-899 (May) 1946.

2. Gross, R. E., and Blodgett, J. B.: Omphalocele (Umbilical Eventration) in the Newly Born, Surg. Gynec. & Obst. 71:520-527 (Oct.) 1940.

3. Moore, T. C., and Stokes, G. E.: Gastroschisis: Report of 2 Cases Treated by Modification of Gross Operation for Omphalocele, Surgery 33: 112-120 (Jan.) 1953.

4. Bernstein, P.: Gastroschisis, Rare Teratological Condition in the Newborn, Arch. Pediat. 57:505-519 (Aug.) 1940.

5. Wyburn, G. M.: Congenital Defects of the Anterior Abdominal Wall, Brit. J. Surg. 40:553-557 (May) 1953.

6. Diller, W. E., and Travis, E. W.: Eventration of the Abdominal Viscera in a Newborn, Ohio M. J. 51:756-757 (Aug.) 1955.

7. Hardaway, R. M.: Gastroschisis, Am. J. Surg. 87:636-638 (April) 1954.

8. Gross, R. E.: A New Method of Surgical Treatment of Large Omphaloceles, Surgery 24: 277-292 (Aug.) 1948.

9. Gyorgy, P.: Personal communication to the author.

10. Cresson, S., and Pilling, G. P., III: Personal communication; Pediatrics, to be published.

Use of Radiophosphorus for Bone Vascularity Determinations

PATRICK G. LAING, M.D.; ALBERT B. FERGUSON Jr., M.D.; LAVERNE VAUGHAN, B.S., and MARY GREBNER, B.S., Pittsburgh

This report presents an attempt to assess some of the problems connected with the use of radiophosphorus as an indicator of bone vascularity. From this account of our experiences with the uptake of radiophosphorus by rabbit bones, some of the factors emerge which may be causing the observed wide variations in the activity of similar areas in different animals.

Previous attempts have been made to determine the viability of bone by using its ability to take up P^{32} from the blood stream as an index (Tucker, 1950).

The notation by Neuman and other workers that the early rapid stage of P^{32} uptake by bone was not a vital process, but, rather, was a purely physicochemical adsorption onto crystal surfaces, has tended to discredit this approach. Tucker found that the ratio of normal bone activity to femoral head activity had to rise to a high value before the femoral head could be presumed dead.

All workers have noted the difficulty of separating soft tissues containing relatively large amounts of P^{32} from the bone to be assayed. This was brought out by Lacroix, Davis, and Schlichs (1952) in a study of the uptake of radiophosphorus by various areas of adult rabbit long bones.

While accepting that the uptake of P^{32} by bone does not give any indication of the viability of the bone, we feel that it does give an index of the availability of the radiophosphorus to the bone crystals. It might also be interpreted as an index of the relative proportion of cortical to cancellous bone with its trapped marrow in any given area. The fact remains, however, that the degree of uptake of P^{32} by any particular area of bone is still dependent on the ability of the ions to reach the area, providing that time is not allowed for diffusion. If time is disregarded as a factor, ions may reach dead bone by diffusion.

Submitted for publication Feb. 8, 1957.

From the Orthopedic Department, University of Pittsburgh School of Medicine.

Background

The uptake of radiophosphorus by bone crystals in vitro has been demonstrated (Weibel, Neuman, and Feldman, 1954) to be a multistep procedure, the first rapid stage of which is a process of surface adsorption and ion exchange between the crystal surface and the surrounding intercellular fluid. In later stages ions move to the deeper layers of the crystals (Stages 4, 5, and 6 of Neuman).

Robinson and Watson (1955) conclude that, although there is a more rapid uptake of P^{32} in newly formed bone, "the degree of hydration and physical state of the organic matrix surrounding the crystals, rather than crystal size, is believed to be the major factor affecting isotope exchange with the crystals."

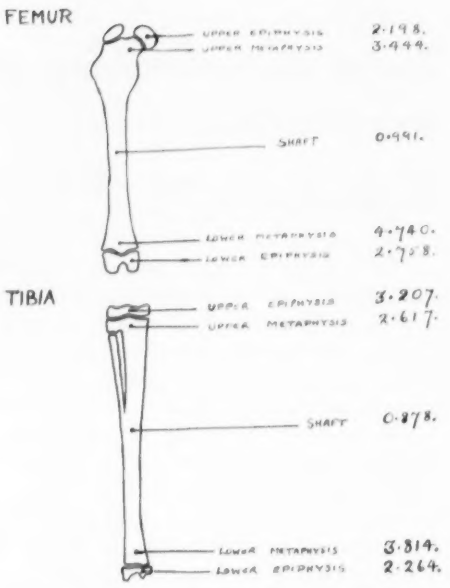
The increase in size of crystals with age noted by these authors is accompanied by an increase in rate of in vitro ion exchange (Amprino, 1952 and 1953), whereas in vivo the more rapid uptake is in younger bone. Notwithstanding the effect of the organic matrix on the uptake of P^{32}, it is felt that the deciding factor in vivo will be the availability of the P^{32} to the bone crystals. The blood supply of the area will determine the amount of radiophosphorus in the "bulk solution" and "hydration layer" of Neuman. If the P^{32} content of the bone is estimated

during or toward the end of Stage 1, i. e., after ion adsorption or exchange with the surface of the crystals, and before the onset of exchange with the deeper layers and recrystallization, then the values should give an indication of the blood supply of the bone. This should be true irrespective of crystal size or age, though some decrease in isotope exchange may be expected on a basis of crystal growth during maturation (Robinson and Watson, 1955).

Methods

From this background, it is apparent that any attempt to correlate the uptake of P^{32} with vascularity of the bone parts must obviate everything except surface adsorption (Neuman's Stages 2 and 3). The time between intravenous injection of the radiophosphorus and the taking of bone samples must be gauged to exclude exchange with the crystal depths and recrystallization: It is felt, working from the uptake curves of Falkenheim, Neuman, and Hodge (1947), that bone samples should be taken 90 minutes after the injection. In this way the stage of rapid uptake is used as a measure of the ability of P^{32} to reach the crystal surfaces via vascular channels and intercellular fluid, before diffusion into the depths of the crystals and recrystallization have entered into the exchange to any degree. Accordingly, 50μc of radiophosphorus in 1 ml. of water was injected into an ear vein of each rabbit. Ninety minutes later the rabbit was killed. One milliliter of blood and bone samples were taken. Five pieces of bone were cut from each femur and tibia, namely, upper epiphysis, upper metaphysis, midshaft, lower metaphysis, and lower epiphysis. A reference sample was taken from the midshaft of the right humerus.

Each bone sample was carefully cleaned mechanically and then washed under a powerful jet of water to remove all soft tissue. The samples were then placed in planchets, previously burned in the muffle furnace and weighed. The samples of both blood and bone were ashed at 600 C in the muffle furnace for two hours. Finally the bone was cooled, crushed to a fine powder, and evenly distributed over the bottom of the planchets. Counts were made using a well Geiger counter in shield and a Multiscaler over two periods of two minutes each, corrected for background, and an average taken. The samples were then weighed and the counts calculated per gram of ashed bone or blood. These counts were then expressed as ratios of the count per gram of the reference area from the midshaft of the humerus.



This diagram of the femur and tibia of the rabbit bears opposite each area of the bone a figure which represents the average of the ratios of radiophosphorus distributed in that area as compared with a standard site in the humerus of the same animal. It is seen that the value is lowest at midshaft and rises in each metaphyseal area. The only area at variance from this finding is the proximal tibia, where the results were not statistically significant.

Results

The results on 10 animals are detailed in the accompanying Table. No correlation could be established between the weight of the animal and the counts obtained per gram of dry blood or bone. The average weight of the animals was 2329 gm. (smallest 1726 gm. and largest 3600 gm.). The average count per gram of ashed bone was 21,780 per minute. All animals were immature, with unfused epiphyses, as determined by inspection at autopsy.

There was a high degree of correlation between the values obtained from corresponding areas of the right and left limbs in the case of both femur and tibia, and thus the values could be grouped for each biopsy site.

Statistically the vascularity of the metaphyseal areas was significantly greater than

Results Expressed as Ratio of Count in Designated Area to Count from Cortical Bone of Right Proximal Humerus in Each Area

Femur			Tibia		
Proximal Epiphysis			Proximal Epiphysis		
Rt.	Lt.		Rt.	Lt.	
2.549	2.275		1.585	1.590	
2.156	2.718	Average	3.176	3.523	Average
3.053	2.806	2.198	4.188	4.107	3.207
1.546	1.406		1.327	2.360	
1.860	1.818	Standard deviation	1.803	1.924	Standard deviation
3.039	2.416	0.643	2.658	4.408	1.971
2.598	3.117		2.457	2.837	
0.965	1.542	Probability	2.079	2.518	Probability
2.657	1.310	<0.0001	2.171	1.766	0.22
2.880	1.465		7.070	9.550	
Proximal Metaphysis			Proximal Metaphysis		
Rt.	Lt.		Rt.	Lt.	
2.790	3.275		2.554	2.172	
2.960	2.339	Average	1.548	2.135	Average
3.470	4.080	3.444	4.425	4.639	2.617
3.129	2.458		1.903	1.853	
2.841	3.191	Standard deviation	2.750	2.300	Standard deviation
4.017	1.372	1.091	1.969	3.937	0.849
3.343	2.451		3.057	2.347	
3.900	3.292	Probability	3.123	2.171	Probability
2.814	2.751	<0.0001	1.970	1.654	<0.0001
5.471	5.246		3.367	2.553	
Midshaft			Midshaft		
Rt.	Lt.		Rt.	Lt.	
0.744	0.749		0.869	0.935	
0.820	0.950	Average	0.656	0.564	Average
1.209	0.752	0.991	0.835	0.629	0.678
0.883	1.037		0.726	0.925	
0.701	0.675	Standard deviation	0.550	0.648	Standard deviation
1.360	2.927	0.462	2.949	1.579	0.530
0.937	0.985		0.751	1.168	
1.096	0.866	Probability	0.613	0.639	Probability
0.832	0.868	0.0001	0.765	0.701	<0.0001
0.817	0.828		0.706		
Distal Metaphysis			Distal Metaphysis		
Rt.	Lt.		Rt.	Lt.	
5.947	4.843		3.095	4.029	
2.508	2.696	Average	3.201	2.435	Average
6.684	6.552	4.740	6.808	1.486	3.814
2.601	2.140		2.957	4.257	
1.889	2.571	Standard deviation	0.819	2.337	Standard deviation
3.984	5.506	3.419	4.602	2.793	2.750
2.267	2.060		1.837	2.011	
2.792	3.195	Probability	2.497	1.792	Probability
2.635	2.648	0.013	3.747	3.116	0.035
5.939	9.855		4.414	4.167	
Distal Epiphysis			Distal Epiphysis		
Rt.	Lt.		Rt.	Lt.	
1.819	1.851		1.465	1.629	
2.051	2.342	Average	1.415	1.168	Average
4.877	2.755	2.758	1.707	4.190	2.264
1.563	1.685		0.928	0.863	
1.942	1.941	Standard deviation	1.267	1.244	Standard deviation
3.986	3.708	1.236	1.510	2.095	2.054
6.425	1.872		1.763	2.004	
2.074	1.831		3.065	1.174	
2.364	1.797		1.442	1.475	
3.482	3.865		10.504	4.221	

the epiphyseal areas in all cases except the upper end of the tibia, where no such a significant difference was seen. The vascularity of the femur was minimal in the cortical bone of the midshaft and increased markedly at both metaphyses, falling significantly at both epiphyses.

Comment

These results point out the difficulties underlying the use of radiophosphorus adsorption by bone as an indicator. This is true regardless of whether one is then attempting to analyze the results as an indication of viability or of vascularity.

The differences existing between the figures for cortical and for cancellous bone and the larger standard deviation in the latter are noteworthy. It is obvious that the rise in the relative amount of marrow may result in this discrepancy. A reflection is seen here of the fact that P^{32} is taken up in large amounts in soft tissue as compared with bone. A small amount of soft tissue therefore markedly influences the result.

It cannot be denied, however, that necrotic marrow, as, for instance, in an avascular head of the femur, would take up little, if any, P^{32}, owing to the lack of blood supply. But once an area has been exposed to radiophosphorus, the height of its activity may be as much a measure of the relative amount of cancellous bone to compact bone as it is a measure of relative vascularity.

The results and method delineated in this paper may aid other workers who attempt to apply radiophosphorus in this manner to estimate the blood supply of bone. Areas such as the femoral head, with its large area of cancellous bone, may prove particularly difficult to evaluate accurately.

Children's Hospital, 125 De Soto St. (13) (Dr. Ferguson).

BIBLIOGRAPHY

Amprino, R.: Autoradiographic Analysis of Distribution of Labelled C and P in Bones, Experientia 8:20, 1952.

Boyd, H. B.; Zilversmit, D. B., and Calandruccio, R. A.: The Use of Radio-Active Phosphorus (P^{32}) to Determine the Viability of the Head of the Femur, J. Bone & Joint Surg. 37-A: 260, 1955.

Cohen, W. E., and Greenberg, D. M.: Studies in Mineral Metabolism with Aid of Artificial Radioactive Isotopes, J. Biol. Chem. 123:185, 1938.

Falkenheim, M.; Neuman, W. F., and Hodge, H. C.: Phosphate Exchange as the Mechanism of Adsorption of the Radioactive Isotope by the Calcified Tissues, J. Biol. Chem. 169:713, 1947.

———Underwood, E. E., and Hodge, H. C.: Calcium Exchange: The Mechanism of Adsorption by Bone of Ca^{45}, J. Biol. Chem. 188: 805, 1951.

Hevesy, G. C.; Levi, H. B., and Rebbe, O. H.: Rate of Rejuvenation of the Skeleton, Biochem. J. 34:532, 1940.

Hodge, H. C.; Van Huysen, G.; Bonner, J. F., and Van Voorhis, S. N.: Adsorption of Phosphate at 40° by Enamel, Dentin, Bone and Hydroxyapatite as Shown by the Radioactive Isotope, J. Biol. Chem. 138:451, 1941.

Jones, D. C., and Copp, D. H.: Metabolism of Radioactive Strontium in Adult, Young, and Rachitic Rats, J. Biol. Chem. 189:509, 1951.

Lacroix, P.; Davis, R., and Schlichs, E.: Distribution of Radiophosphorus in the Long Bones of Adult Rabbits, Experientia 8:113, 1952.

Leblond, C. P.; Wilkinson, G. W.; Bélanger, L. F., and Robichon, J.: Radio-Autographic Visualization of Bone Formation in the Rat, Am. J. Anat. 86:289, 1950.

Manly, M. L., and Bale, W. F.: Metabolism of Inorganic Phosphorus of Rat Bone and Teeth as Indicated by Radioactive Isotope, J. Biol. Chem. 129:125, 1939.

———Hodge, H. C., and Manly, M. L.: Relation of the Phosphorus Turnover of the Blood to the Mineral Metabolism of Calcified Tissues as Shown by Radioactive Phosphorus, J. Biol. Chem. 134:293, 1940.

Robinson, R. A., and Watson, M. L.: Crystal-Collagen Relationships in Bone as Observed in the Electron Microscope, Ann. New York Acad. Sc. 60:596, 1956.

Management of Intussusception in Infants and Children

JULES F. LANGLET, M.D., and DONALD P. CHANCE, M.D., Danville, Pa.

Introduction

Intussusception is the telescoping of a portion of the intestine into an adjacent segment of bowel. The occurrence of this in infants and children constitutes one of the commonest abdominal emergencies and is seen most frequently in the first two years of life.

This telescoping of the intestine may occur at any level in the intestinal tract, but most frequently at the ileocolic junction. When the intussusception originates in the colon, ileocolic junction, or lower ileum, it may be reduced by air insufflation or enemata. When irreducible by conservative measures, or when the intussusception is proximal to the terminal ileum it constitutes a surgical emergency.

At the time of operation, many of these intussusceptions can be reduced by manual taxis, as first advocated by Hutchinson.[1] However, a certain number will be found to be irreducible or gangrenous, and until the past decade these carried an exceedingly high mortality. Because of this, a variety of surgical procedures were devised, the two most frequently used being resection with immediate anastomosis and resection with formation of a double-barreled enterostomy followed by subsequent closure. Within the past decade, with improved supportive measures associated with modern pediatric and anesthetic care, the mortality has been greatly reduced. With this care available, it is now felt that the majority of these patients can be safely carried through a resection with immediate anastomosis, the exteriorization procedure being reserved for those whose general condition at the time of surgery is poor.

Submitted for publication Jan. 18, 1957.

Resident in General Surgery (Dr. Langlet); Associate in Department of General Surgery (Dr. Chance), The George F. Geisinger Memorial Hospital and The Foss Clinic.

This paper is an extension of the prize-winning essay, "Intussusception in Infants and Children, with Emphasis on Primary Resection with End-to-End Anastomosis," sponsored by the Committee on Trauma of the Central Pennsylvania Chapter of the American College of Surgeons. The essay was read at the annual meeting of the Central Pennsylvania Chapter of the American College of Surgeons, Williamsport, Pa., April 14, 1956.

Material

All the records of intussusception in infants and children seen at the Geisinger Memorial Hospital and The Foss Clinic from 1945 to 1955, inclusive, were reviewed. In this period, 19 children were admitted with an acute intussusception. The type is given in Table 1. The etiologic agent was determined in three cases, being a Meckel diverticulum in two and an ileal polyp in one. In the remainder, the intussusception was of the idiopathic variety. The age range was from one month to 2½ years. Fourteen occurred in boys and five in girls.

TABLE 1.—*Types of Intussusception in Nineteen Infants and Children, 1945-1955*

	Male	Female
I. Ileoileal	1	
II. Ileoileocolic	1	1
III. Ileocolic		
(*a*) Extending to cecum (ileocecal)	2	
(*b*) Extending to midportion of ascending colon	2	
(*c*) Extending to hepatic flexure	3	1
(*d*) Extending to midportion of transverse colon	4	
(*e*) Extending to splenic flexure	1	3
	12	4
Total	14	5

TABLE 2.—*Method of Reduction in Nineteen Cases of Intussusception*

I.	Barium enema under fluoroscopic control	
	(*a*) Reduction	6
	(*b*) Nonreduction	10
II.	Surgical exploration	
	(*a*) No reduction necessary	2
	(*b*) Manual reduction	7
	(*c*) Resection with primary anastomosis	4

The history most commonly given by the parents was that of a well baby who suddenly began to have acute, colicky abdominal pain, which recurred and was associated with vomiting and the passage of bloody stools. The general condition of the baby was dependent upon the duration of the symptoms. If seen shortly after onset, the child appeared relatively well, but if the duration of symptoms had been long, the baby appeared pale, listless, dehydrated, and acutely ill, with a rapid pulse. The abdomen was frequently distended, and palpation often disclosed a sausage-like mass. On rectal examination, blood was a common finding.

The method of management of these cases is summarized in Table 2. A barium enema study was performed in 16 cases for both diagnostic and therapeutic purposes. In six cases a successful reduction of the intussusception was achieved, and after a satisfactory period of observation these infants were dismissed from the hospital without further therapy. In nine patients no reduction or an incomplete reduction was achieved. In the one patient with an ileoileal intussusception the barium enema study was within normal limits. In three cases no barium study was carried out.

Thirteen patients required surgical management. In two cases, proved by barium enema, spontaneous reduction had occurred. In seven cases the reduction was completed by manual taxis, while in four cases the intussusception was irreducible or gangrenous and required a resection. There were no deaths in this group of 19 patients.

The four cases of irreducible or gangrenous intussusception which required resection had an immediate end-to-end anastomosis. These cases are reported in detail.

Report of Cases

CASE 1.—A white male infant 8 months of age was admitted on the pediatric service on Feb. 22, 1950, with a four-day history of abdominal pain, vomiting, and the passage of bloody stools. Examination on admission disclosed a lethargic, dehydrated baby with a rectal temperature of 101 F, pulse of 120, and respiration of 36. Tenderness in the right side of the abdomen was noted, but no masses were palpated either abdominally or rectally.

Laboratory findings included a normal urine, a hemoglobin of 62%, an erythrocyte count of 3,410,000, and a leukocyte count of 12,400, with a normal differential count. A roentgenogram of the abdomen revealed a small-bowel obstruction, and intussusception was suggested as a possibility. A barium enema study was carried out, which disclosed an intussusception extending to the hepatic flexure.

Preparation for surgery consisted of gastric decompression, antibiotics, whole-blood transfusion, and parenteral fluids and electrolytes. Exploration was carried out by Dr. H. M. Klinger through a right rectus muscle-splitting incision, on Feb. 23, with the patient under open drop ether anesthesia. An irreducible gangrenous, ileocolic intussusception was found, and a right hemicolectomy was carried out, with an end-to-end ileotransversecolostomy.

Postoperatively the patient was supported with antibiotics, oxygen, gastric suction, whole-blood transfusion, and parenteral fluids and electrolytes. Formula was started on the third postoperative day. The remainder of the convalescence was uneventful. The incision healed primarily, and the infant was dismissed from the hospital on the 11th postoperative day, having normal stools and taking his usual formula.

Fig. 1 (Case 1).—Terminal ileum and right colon. The cecum was grossly edematous, the wall being 2 cm. thick in some places.

CASE 2.—A white girl 3½ months of age was admitted on the pediatric service on Aug. 5, 1954, with a two-day history of refusing her formula, and irritability. On the day of admission she vomited her formula on one occasion.

Physical examination revealed a well-developed, well-nourished, slightly lethargic infant with a normal temperature, pulse, and respiration. There was evidence of nasopharyngitis and otitis media on the right. Examination of the abdomen revealed some muscle guarding and tenderness in the right lower quadrant.

Laboratory findings included a normal urine, a hemoglobin of 10.8 gm. per 100 cc., an erythrocyte count of 3,540,000, and a leukocyte count of 15,900, with a differential count of 63 neutrophils, 36 lymphocytes, and 1 monocyte. The stool was positive for occult blood by the guaiac test. A roentgenogram of the abdomen disclosed a small-bowel obstruction. Barium enema demonstrated an intussusception which extended to the splenic flexure. The intussusception was reduced to the ileocecal valve, but it was not possible to reduce the ileal component of the intussusception.

Preparation for surgery included a whole-blood transfusion, gastric decompression, antibiotics, parenteral fluids, and electrolytes. On Aug. 8, exploration was carried out by one of us (D. P. C.) through a primary right lower quadrant transverse incision, with retraction of the rectus muscle medially. Open drop ether and oxygen anesthesia was used. The ileocolic portion of the intussusception had recurred, and the head of the intussusception was in the midtransverse colon. Reduction was accomplished, but when the ileoileal portion of the intussusception was reduced, the leading point of the intussusception was found to be a Meckel diverticulum. The ileum adjacent to this was gangrenous for a distance of 4 in. (10 cm.). The portion of the gangrenous ileum with the Meckel diverticulum was resected and an end-to-end ileoileostomy carried out.

Postoperatively, supportive treatment consisted of gastric suction, antibiotics, whole-blood transfusion, and parenteral fluids and electrolytes. The patient began to pass stools the day of operation. Formula was started on the fourth postoperative day and rapidly advanced to the child's usual intake. The incision healed primarily, and the infant was dismissed from the hospital on the 12th postoperative day, eating and gaining normally.

CASE 3.—A white male infant 8 months of age was admitted on the pediatric service on July 1, 1955, with a history of cramping abdominal pain and refusal to eat of three and one-half hours' duration.

Physical examination revealed a well-developed, well-nourished child, who alternately slept and cried out with cramping abdominal pain. The temperature, respiration, and pulse were normal. Examination of the abdomen showed a sausage-shaped, tender mass in the left upper quadrant.

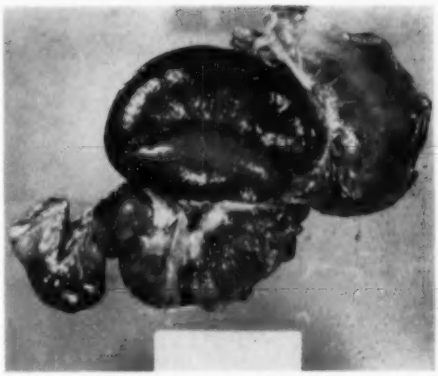


Fig. 2 (Case 3).—The ileoileal intussusception was in the upper portion of the ileum. The resected specimen of small bowel was gangrenous.

Laboratory studies disclosed a normal urine, a hemoglobin of 11.3 gm. per 100 cc., an erythrocyte count of 4,120,000, and a leukocyte count of 13,300, with a differential count of 16 neutrophils, 6 band forms, 1 eosinophil, 31 lymphocytes, and 2 disintegrated cells. A roentgenogram of the abdomen disclosed a single dilated loop of small intestine in the midportion of the abdomen. A barium enema study was normal.

The patient was prepared for surgery with a whole-blood transfusion, started on antibiotics, and given intravenous fluids and electrolytes. Exploration was carried out by one of us (D. P. C.) through a primary left upper quadrant transverse incision, with the patient under endotracheal cyclopropane anesthesia. The operation was performed eight hours following the onset of pain. The patient was found to have a irreducible, gangrenous ileoileal intussusception in the upper portion of the ileum. This portion of the ileum was resected and an end-to-end ileoileostomy carried out.

Postoperatively, supportive therapy consisted of gastric suction, antibiotics, oxygen, whole-blood transfusion, parenteral fluids, and electrolytes. The patient was started on formula on the sixth postoperative day. The incision healed primarily, and the infant was dismissed from the hospital on the 13th postoperative day.

CASE 4.—A white male infant 10 months of age was admitted on the pediatric service on Aug. 24, 1955, with a three-day history of vomiting. Since onset the patient had one normal stool, but none in the past two days.

Examination on admission disclosed an acutely, extremely ill, pale, dehydrated child. The abdomen was markedly distended and diffusely tender, with

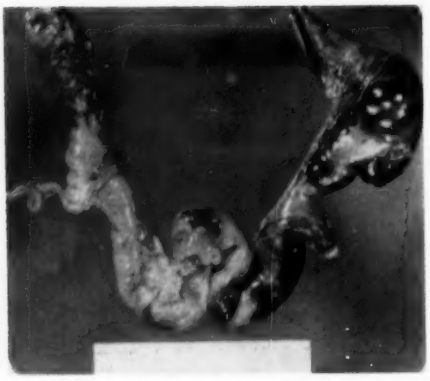


Fig. 3 (Case 4).—Resected specimen consists of the terminal portion of the ileum to the transverse colon. The leading point of the intussusception could be palpated in the middle of the transverse colon. After resection, the intussusception was reduced in the pathology laboratory. The Meckel diverticulum, terminal ileum, cecum, appendix, and ascending colon can be readily recognized.

some resistance in the right upper quadrant. The temperature was 100 F rectally, pulse 130, and respiration 44.

Laboratory studies included urinalysis, which was normal except for occasional leukocytes and 2 hyaline casts per low-power field. The hemoglobin was 15.4 gm. per 100 cc., the erythrocyte count 4,200,000, and the leukocyte count 7550, with a differential count of 35 neutrophils, 34 band cells, 29 lymphocytes, and 2 monocytes. The nonprotein nitrogen was 46 mg. per 100 ml.; blood sugar, 119 mg. per 100 ml.; plasma chlorides, 90 mEq. per liter; carbon-dioxide capacity 19.6 mEq. per liter; serum potassium 3.0 mEq. per liter, and serum sodium 131 mEq. per liter. A roentgenogram of the abdomen demonstrated a small-intestinal obstruction in the lower ileum. A barium enema revealed an intussusception extending to the splenic flexure. Reduction to the lower ascending colon was carried out by barium enema.

The patient was prepared for surgery by gastric decompression, antibiotics, whole-blood transfusion, and parenteral fluids and electrolytes. Exploration was carried out by Dr. W. T. Barnes through a right upper rectus incision with the patient under endotracheal cyclopropane and ether anesthesia. An irreducible and gangrenous ileoileocolic intussusception, with a Meckel diverticulum as the leading point, was resected. Intestinal continuity was reestablished by means of an end-to-end ileotransversecolostomy.

Postoperative supportive therapy consisted of gastric suction, antibiotics, oxygen, whole-blood transfusion, parenteral fluids, and electrolytes as indicated. Formula was begun on the 8th postoperative day, and the child was dismissed from the hospital on the 18th postoperative day, eating normally and with his incision well healed.

Comment

Although intussusception was first recognized by Hippocrates, who suggested treating it by inflation of the bowel from below, it was not until 1789 that John Hunter accurately described the specimen from a fatal intussusception in a 9-month-old child. The condition was little noted until 1873, when Jonathan Hutchinson reported a successful operation on a 2-year-old child which had been performed in 1871. In 1875 Hutchinson[2] reported a second case, in a 6-month-old infant, and, though this patient died postoperatively, it was in this report that Hutchinson classically described the method of operative manipulation which is still used for reducible intussusceptions.

That intussusception could be successfully reduced by enemas was first shown by Hirschsprung.[3] Because of his influence, this method had wide use throughout the Scandinavian countries, and they obtained a lower mortality than by surgical treatment. With the introduction of the barium enema under fluoroscopic control, in 1927, this method of reduction received even wider use. Today in Denmark reduction is first attempted by barium enema in 96.7% of all cases, and over half the intussusceptions are successfully reduced by this means.[4]

Within recent years, the barium-enema method of reduction has been more widely used in this country. In 1954 Ravitch[5] reported the successful reduction in 77% of 65 cases, thereby avoiding an operation.

Modern-day management of intussusception in infants and children requires the coordinated efforts of a group of specialists, including pediatrician, roentgenologist, and surgeon. With such a team available, the arguments against an attempt at barium-enema reduction are without a good foundation. As soon as the pediatrician suspects intussusception, both the roentgenologist and the surgeon may be alerted, and a barium enema may be administered while

the operating room is being prepared for surgery. If the reduction is unsuccessful, immediate surgery may be performed.

At exploration, it may be found that reduction has been completed by barium enema or occurred spontaneously during the administration of anesthesia. Other intussusceptions will require reduction by taxis, while some will be found irreducible or gangrenous.

Until the past decade, the intussusception at the time of operation found to be irreducible or gangrenous has always been attended by an exceeding high mortality. Between 1907 and 1947 McLaughlin[6] collected from the literature 200 cases which had been treated surgically, with a 69% mortality.

Because of this mortality, a variety of ways of surgical management have been proposed. In general, they fall under one of the following categories: (1) resection with immediate anastomosis; (2) resection with formation of a double-barreled enterostomy and subsequent closure; (3) suture of the serosa of the invaginated barrel of the intussuscipiens, followed by resection of the gangrenous intussusception through an incision in the ensheathing bowel; (4) lateral anastomosis about the lesion, leaving the intussuspection in situ, or exteriorizing it and subsequently resecting it; (5) ileostomy with secondary resection, and (6) various combinations of the above procedures. Today the two most frequently advocated are resection with immediate anastomosis and resection with formation of a double-barreled enterostomy with subsequent closure.

Within the past decade, with a better understanding of the management of fluids and electrolytes in infants and children, antibiotics, and improved pediatric and anesthetic care, the mortality has been greatly reduced. With this care available it is now being shown that the majority of these patients can be safely carried through a resection with immediate anastomosis. Dennis,[7] in reporting eight consecutive successful resections, seven with an immediate anastomosis, demonstrated for the first time that with meticulous surgical technique and thorough postoperative care the occasional success with immediate anastomosis could be repeated in a small, but significant, number of cases.

Thatcher[8] reported a 6% mortality in 15 cases requiring resection from 1947 to 1953, whereas in 20 cases prior to 1947 there had been a 55% mortality. Similarly, Packard,[9] in comparing cases for the two periods of 1934 to 1944 and 1944 to 1954, found a 50% mortality in four cases in the first period and no mortality in eight cases in the second period. Success in the four cases in this report lends support to the school that advocates resection with immediate anastomosis.

Summary

A review of 19 consecutive cases of intussusception in infants and children from 1945 to 1955 is presented. There were no deaths.

In six cases the intussusception was reduced by barium enema.

Thirteen cases had surgical exploration. In two cases the reduction was found complete. Reduction was achieved by manual taxis in seven cases. In four cases the intussusception was irreducible or gangrenous and required resection.

The four cases requiring resection were managed by immediate end-to-end anastomosis.

Success in the four cases requiring resection with immediate anastomosis is attributed to careful preoperative and postoperative fluid and electrolyte management, antibiotics, and supportive therapy.

The George F. Geisinger Memorial Hospital and The Foss Clinic.

REFERENCES

1. Hutchinson, J.: A Successful Case of Abdominal Section for Intussusception, with Remarks on This and Other Methods of Treatment, Tr. Roy. Med.-Chir. Soc. Glasgow 57:31-75, 1874.

2. Ravitch, M. M.: Jonathan Hutchinson and Intussusception, Bull. Hist. Med. 25:342-353, 1951.

3. Hirschsprung, H.: Et tilfælde af subakut tarminvagination, Hospitalstid 3:321, 1876.

4. Nordentoft, J. M., and Hensen, H.: Treatment of Intussusception in Children: A Brief Survey Based on 1838 Danish Cases, Surgery 38: 311-319, 1955.

5. Ravitch, M. M.: Reduction of Intussusception by Barium Enema, Surg. Gynec. & Obst. 99:431-435, 1954.

6. McLaughlin, C. W., Jr.: Surgical Management of Irreducible Intussusception, Arch. Surg. 56:48-57, 1948.

7. Dennis, C.: Resection and Primary Anastomosis in the Treatment of Gangrenous or Non-Reducible Intussusception in Children: A Safe, Simple, One-Layer Silk Anastomosis, Ann. Surg. 126:788-796, 1947.

8. Thatcher, D. S.: Intussusception in Infants and Children, Ann. Surg. 140:180-184, 1954.

9. Packard, G. B.: Treatment of Intussusception in Infancy and Childhood, Pediatrics 15:291-297, 1955.

Serum Amylase Test in Differential Diagnosis of Freely Perforated Ulcer and Acute Pancreatitis

A Reevaluation

SIDNEY A. ROSENBURG, M.D., and SERMET AKGUN, M.D., Pittsburgh

There are very few laboratory tests that can be depended upon per se to make a clinical diagnosis, and indeed the man who is wont to make a diagnosis on such evidence alone is certain to rue the day. However, there are a few tests which, when properly and competently executed, are reliable in clinching a differential diagnosis among several clinical possibilities. Such a test in our experience has been the serum amylase test in establishing a differential diagnosis between perforated ulcer and acute pancreatitis. Bockus [1] has said:

> An immediate determination of the serum amylase may be helpful if acute pancreatitis is to be considered. If the serum amylase is markedly elevated, a primary diagnosis of acute pancreatitis is justified since perforated peptic ulcers rarely increase the concentration of the pancreatic enzymes in the blood.

In our laboratory, the Somogyi test is used, and the limit of normal has been 60 to 200 units. Let us assume that we have a patient with an acute condition of the abdomen who presents a rigid abdominal wall with some degree of shock. The flat plate of the abdomen shows no free air in the erect position. In our past experience the serum amylase could be depended upon (if taken within the first 48 hours) to make the diagnosis of acute pancreatitis in the presence of figures which were elevated beyond question. Certainly, with reports in our laboratory in the neighborhood of 1000 units, there was no question about the diagnosis of acute pancreatitis in the clinician's mind. In previous years the differential diagnosis was not too important, because both perforated ulcer and acute pancreatitis demanded immediate operative intervention. Today, the ability to make this certain diagnosis is of great importance, because perforated ulcer, in most hands, demands immediate operation but acute pancreatitis is now treated conservatively for best results. Thus, the acceptance of the greatly elevated amylase as the final deciding factor in the diagnosis means that no operative intervention would be undertaken.

Until recently, this basis was the one upon which we worked, knowing full well that in the occasional penetrating ulcer it is possible to get moderate elevation of the serum amylase, due to the localized involvement of the pancreas. In our laboratory, these figures would range from 300 to 500 units as the maximum. Probstein and associates [2] stated:

> Blood diastase determinations are normal or subnormal in anterior perforated ulcer and moderately raised in posterior perforated ulcers near the pancreas. This helps to differentiate perforated ulcer from acute pancreatitis where the diastase is very high.

Inasmuch as cases of perforated ulcer are not immediately operative, a mistaken diagnosis in this instance would not be fatal. In the past year, there have been two acute abdominal cases in which the serum amylase reached levels of 812 units, in one instance, and 1200 units, in the other. The diagnosis in both cases was thought to be acute pancreatitis, but it was subsequently proved to be freely perforated ulcer: one duodenal

Submitted for publication Oct. 26, 1956.

Senior Attending Surgeon, Montefiore Hospital and Homestead Hospital, Homestead, Pa. (Dr. Rosenburg). Resident in Surgery and Pathology, Montefiore Hospital (Dr. Akgun).

and the other gastric. In both cases, flat plates of the abdomen were taken (in the erect position), and they failed to reveal any free air.

Report of Cases

CASE 1.—A 73-year-old white man, admitted Oct. 29, 1955.

Chief complaint: Pain in the chest.

X-rays showed a right pleural effusion, with the suggestive process at the right apex. The patient improved with pleural taps. About 26 days after admission, pain and tenderness developed in the right upper abdominal quadrant. Rigidity became diffuse. A flat plate of the abdomen in the erect position showed no free air. Serum amylase was 812 units. On the basis of this finding, a diagnosis of acute pancreatitis was made. Surgery was not undertaken, and the patient died 48 hours later. Permission for autopsy was obtained. The following significant findings were present: (1) large ruptured chronic duodenal ulcer, site second portion of duodenum; (2) chemical peritonitis—lesser and greater peritoneal sacs; (3) bilateral healed pulmonary tuberculosis with hydrohematothorax; (4) no significant pancreatic changes.

CASE 2.—A 65-year-old white man was admitted following an accident with injury to right shoulder. He complained of severe pain in the right shoulder and abdominal pain. Abdominal tenderness and rigidity were generalized, and the patient was in quite a degree of shock. X-rays showed a fracture of the right humerus, and a flat plate taken for free air failed to disclose any present. The patient continued to get progressively worse. Peristalsis was completely absent. The serum amylase determination showed 1200 units. The patient died 24 hours after admission. Autopsy disclosed the following significant findings: (1) large ruptured gastric ulcer, located 4 cm. proximal to pylorus in posterolateral position near the greater curvature; (2) peritonitis; (3) fracture of right shoulder; (4) no significant pancreatic changes.

Comment

In trying to account for the elevated blood amylase in both cases, one is inevitably drawn to the following conclusion: An outpouring of duodenal contents, high in amylase, into the free peritoneal cavity must result in a rapid absorption of the amylase into the blood stream via the broad absorbing peritoneal surface. This is probably more likely to happen if the perforation is of large size and if the perforation occurs after a meal, when the amylase content of the duodenal juices would be high. It is less likely to be present if the perforation occurs on an empty stomach and the opening is a small one. Wapshaw [3] came to the conclusion that the greatly elevated amylase figures in his cases of perforated ulcer were present when the time lapse following the meal was the greatest.

Musgrove,[5] of the Mayo Clinic, reported three cases of free gastroduodenal perforation with elevated blood amylase figures, varying from 500 to 800 units.

Mahaffey [6] very recently reported a series of cases of perforated ulcer in which the amylase determinations were performed. He came to the conclusion that the amylase concentration was elevated only in patients who had ingested food or alcohol three hours prior to perforation. He also felt that the size of the perforation and the degree of spillage into the peritoneal cavity were factors in the elevated levels. He further stated: "An elevated amylase concentration occurred most often when the interval following perforation was greater than 12 hours."

It occurred to us that perhaps this theory could be proved in the laboratory. Perusal of the literature disclosed the fact that Pemberton and associates, of the Mayo Clinic,[4] had attempted to prove a similar theory, using the dog as the experimental animal. In our experiments the rabbit was utilized.

It became apparent that free duodenal juices in the peritoneal cavity as the result of operative incision in the duodenum caused a rapid rise in serum amylase figures. This became more evident as the time element increased and also following incision of the duodenum after a full meal. The simple injection of duodenal juices into the peritoneal cavity (by syringe and needle) also resulted in a similar rise.

There seems to be little doubt either clinically and experimentally that a free perforation of the duodenum can result in elevated amylase levels. We admit that moderately elevated levels can result from pene-

trating posterior ulcer with pancreatic involvement and with the use of morphine and its derivatives. We wish to emphasize that much higher levels, consistent with the diagnosis of acute pancreatitis, can be had in free anterior perforations of the duodenum or stomach without pancreatic involvement. We think it is highly important to stress this point, because amylase levels may well be the factor to keep the surgeon from performing a laparotomy which the patient direly needs.

Given such a case as this with free air under the diaphragm, there is no problem, even though the amylase may be high. However, what of the abdominal catastrophe with no free air and markedly elevated amylase levels? Withholding operation from a case of perforated ulcer on the basis of an amylase report may prove fatal. On the other hand, operating in a case of acute pancreatitis to rule out a perforated ulcer may also result in unnecessary fatality.

It occurred to us that a simple diagnostic procedure could be of great help in this dilemma. Given such a case as has been postulated, peritoneal aspiration in the right or left lower quadrant with an 18-gauge needle and syringe, under local anesthesia, might be of inestimable value. The aspiration of bile-stained fluid or the type of cloudy exudative fluid seen late in perforated ulcer could establish the diagnosis even in the presence of high serum amylase and in the absence of free air under the diaphragm. With these findings, surgery should not be unduly delayed, and doubt should be resolved.

Conclusion

It is our feeling that surgeons have been wont to be lulled into a nonoperative state of mind with the receipt of a laboratory report showing markedly elevated serum amylase figures. It is the purpose of this paper to alert them to the fact that the serum amylase test, although a most valuable one, must be interpreted in the light of this discussion. When one is in doubt as to which course to pursue, peritoneal aspiration may give very valuable information.

Dr. S. Isaacson and Dr. M. S. DeRoy gave us permission to use their cases.

3500 Fifth Ave. (13).

REFERENCES

1. Bockus, H. L.: Gastro-Enterology, Philadelphia, W. B. Saunders Company, 1943, Vol. I, p. 509.

2. Probstein, J. G.; Wheeler, P. A., and Gray, S. H.: J. Lab. & Clin. Med. 24:449-452, 1939.

3. Wapshaw, H.: Lancet 2:414-415, 1949.

4. Pemberton, A. H.; Grindlay, J. H., and Bollman, J. L.: Proc. Staff Meet. Mayo Clin. 25: 5-8, 1950.

5. Musgrove, J. E.: Proc. Staff Meet. Mayo Clin. 25:8-10, 1950.

6. Mahaffey, J. H.; Brockman, H. L.; Jordan, G. L., Jr., and Howard, G. M.: Surg. Gynec. & Obst. 101:129-132, 1955.

Surgical Pathology of Fungus Diseases

JAN SCHWARZ, M.D., and GERALD L. BAUM, M.D., Cincinnati

Fungus diseases are frequently diagnosed or treated surgically. The tissues most frequently received for diagnosis of fungus diseases are lymph nodes, skin, and lung, and occasionally brain, bone, etc.

Lymph nodes from the neck, especially the ones located in the fat pad of the scalene region, often contain satellite lesions of which the primary is in the lung.[44] The morphological diagnosis of granulomatous disorders has limitations and should be supplemented by cultural procedures.[50]

We place part of the biopsy material into a refrigerator freezing compartment for 24 hours, by which time the microscopic sections become available. We then culture all lymph nodes except those containing metastatic carcinoma. In view of the relatively frequent association of lymphomas with Cryptococcus neoformans and Histoplasma capsulatum, cultures are, in our opinion, very much indicated even if a clear-cut lymphoma has been recognized.[29,45] The results of the culture may become decisive in cases where we fail morphologically to demonstrate or identify fungi in the tissues.

Frequently organisms are clearly demonstrable by one or several of the special staining procedures, but the cultures may be negative. Our conclusion in such cases must be that the organisms are not viable but still retain their characteristic staining pattern.

All the materials which might be contaminated are mixed with antibiotics and injected intraperitoneally into mice, and cultures are taken after four weeks from the livers and spleens of these animals. Contaminating saprophytes are largely eliminated through the animal inoculation. Cyclohexiimide (Actidione) added to culture media inhibits the growth of saprophytic fungi, and such media may permit direct cultures without the use of animals.[15]

Culture is also desirable to substantiate the diagnosis because morphologically the size of many of the deep fungi varies greatly. In recent years fungus diseases are more frequently suspected and diagnosed than ever before. It is imperative to avoid "false-positive" identification, mistaking artifacts for organisms.

Submitted for publication Nov. 7, 1956.

From the Clinical Laboratories, Jewish Hospital, and the Laboratory of Mycology, Departments of Dermatology and Pathology, Cincinnati General Hospital.

This research has been supported partially by Grant E-576 from the National Institutes of Health.

North American Blastomycosis

North American blastomycosis is a disease which is found almost exclusively on

Size and Recommendations for Staining of Some Fungus Cells in Human Tissues

	Average Size, μ	Variations of Size Observed by Authors, μ	Recommended Stains *
Blastomyces dermatitidis	7–20	2–30	Gri, Gro, PAS
Blastomyces brasiliensis	10–30	8–80	Gri, Gro, PAS
Histoplasma capsulatum	2–5	1–20	Gri, Gro
Cryptococcus neoformans	5–15	3–20	Mucicarmine, Gri
Candida albicans	3–6	1–7	PAS, Gri
Coccidioides immitis			
Spherules	10–60	5–240	Gri
Endospores	1–10	1–30	Gri, Gro

* The choice of stains is in the sequence mentioned in the Table: Gri stands for Gridley; Gro, Grocott; PAS, periodic acid-Schiff reaction.

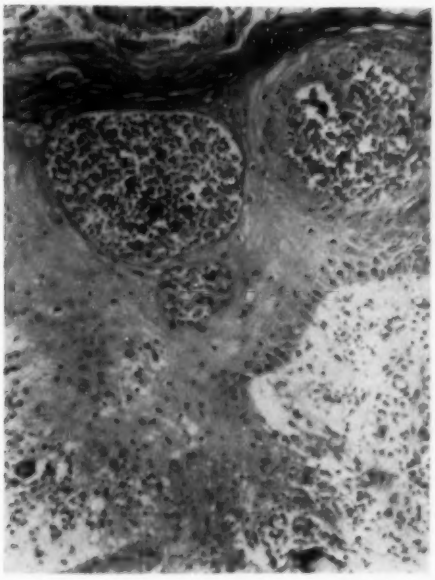


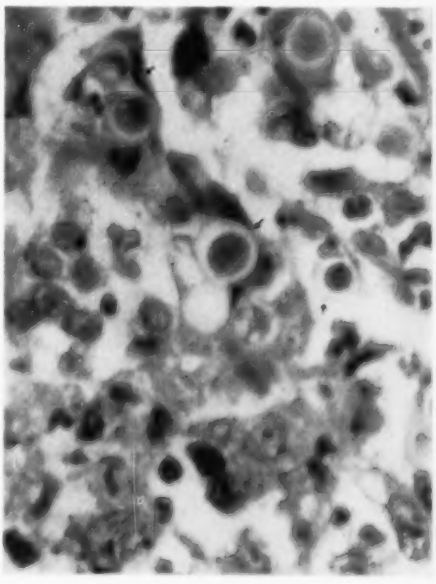
Fig. 1.—Pseudoepitheliomatous hyperplasia of skin in North American blastomycosis. Intraepithelial microabscesses are often teeming with organisms. A variable number of giant cells, sometimes engulfing organisms, can be found. Hematoxylin and eosin; reduced to 2/3 of mag. × 150.

this continent. It is not a common disease, but a survey made two years ago showed that cases are observed with regular frequency in Wisconsin, Illinois, Ohio, Indiana, Kentucky, Tennessee, and North Carolina.[43] The organ most frequently submitted for study by the surgeon is the skin. Blastomycosis, however, is essentially a pulmonary disease, and the skin manifestations are, in almost all cases, secondary.[39,40] Only a few verified primary skin infections have been observed, and those always in people in the laboratory.[52] If the lung focus is arrested, the submitted cutaneous lesion may be the only one and the removal may be therapeutic as well as diagnostic. If the lung lesion is active, then multiple cutaneous lesions may be found.

Roughly described, the typical cutaneous lesion of blastomycosis is generally warty with central ulceration. The history often reveals that the lesion started as a pimple or vesicle. After the lesion breaks open, induration of the borders ensues, with centrifugal enlargement. Microabscesses are often found on the outer angle of the border. These, by the way, are the ideal points for aspiration and direct demonstration of the organisms. With the tip of the needle one generally obtains just a small drop of pus, which may be found to be teeming with yeast cells.

In 1949, a 38-year-old white female school teacher complained of an infection about the nail of her right large toe. Even after removal of the nail and extensive medication and x-ray therapy, the lesion did not improve. She remained under the care of a competent dermatologist for four years. In 1953 a granulating area of 5×2 cm. was discovered on the dorsum of the large toe. The lesion was tender and had irregular papillary, slightly elevated borders. A biopsy revealed the presence of Blastomyces dermatitidis and pseudoepitheliomatous hyperplasia of the epidermis. The big toe was amputated and the patient dismissed seven days later. This case illustrates the need for biopsy and the quick results of surgical treatment in the presence of arrested pulmonary blastomycosis.[28]

Fig. 2.—Blastomyces dermatitidis in pulmonary blastomycosis. In tissues the organism is round, 8μ to 24μ in diameter, and has characteristically a single bud with a broad base (central arrow). It looks like the figure eight. Hematoxylin and eosin; reduced to 2/3 of mag. × 1050.



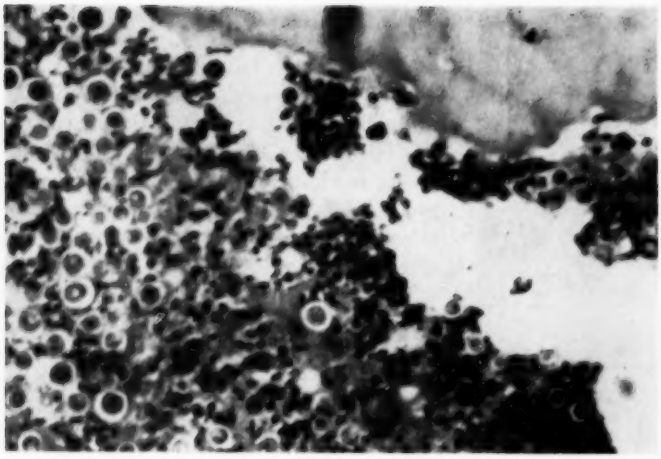


Fig. 3.—Bone and bone marrow may become invaded in disseminated blastomycosis. The yeast cells may replace the bone marrow or may produce tubercle-like structures. Hematoxylin and eosin; reduced to 73% of mag. × 400.

The outstanding features of the microscopic picture are pseudoepitheliomatous hyperplasia and the presence of intraepithelial and dermal microabscesses. The thickening and proliferation of the surface epithelium are so remarkable that the lesion can easily be mistaken for neoplasm. Ordinarily one observes plasma cells and leukocytes in the corium, a fair number of which may be eosinophils. Giant cells may be few in number or may be quite prominent. Organisms may be present, either free or in the giant cells. Such an organism has a broad, refractile wall. If, in addition, a single bud with a broad base is found, the diagnosis is confirmed. It may be necessary to use special stains in order to demonstrate the Blastomyces. The Bauer, Hotchkiss-McManus, Gridley, and Grocott methods give excellent results.[4,18,19,22,25] The periodic acid-Schiff stain shows either a red disc or a sharply outlined ring, but, according to our experience, it may be impossible to differentiate Blastomyces dermatitidis morphologically from Candida, Cryptococcus, isolated endospores of Coccidioides immitis, and large forms of H. capsulatum and from Blastomyces brasiliensis. The possibility of confusion with the endospores of Coccidioides is obvious, since they vary greatly in size. A few words, however, must be said about the other fungi mentioned.

H. capsulatum in tissue is, as a rule, 1μ-5μ in size, but larger forms, up to 16μ and more, have been observed in human cases,[6,38,49] especially in necrotic tissue. Culture and additional evidence of historical or serological nature may be necessary for diagnosis.

Candida may be a problem of differential diagnosis in tissues, but not in the skin, because it does not produce a pseudoepitheliomatous reaction, as does Blastomyces.

Cryptococcus can be very difficult to recognize if only a few organisms are present and if there is no well-developed capsule, a situation which is not uncommon. The mucicarmine stain permits a definitive diagnosis of C. neoformans, however.

The foregoing discussion underlines the fact that even in the most experienced hands insolvable problems are inevitable and that cultural methods should be used to supplement and confirm suspicions based on morphological observation.

Other biopsy tissue in which Blastomyces can easily be overlooked comes from the larynx, and less frequently from the bronchus. In the larynx one observes either a pseudoepitheliomatous reaction or a simple granulomatous lesion. In pulmonary tissue the whole gamut of pathology can be found, something which should be anticipated of a granulomatous pulmonary disorder severe

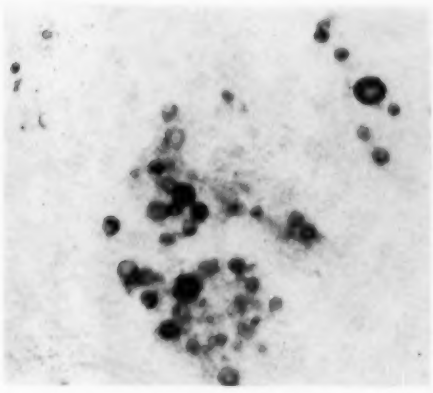


Fig. 4.—The great variation in the size of yeast cells makes definitive diagnosis difficult; positive identification by culture is highly desirable. This particular field could represent B. dermatitidis, endospores of C. immitis, or giant forms of H. capsulatum or C. neoformans. Blastomyces dermatitidis was actually identified by culture. Gridley stain; reduced to 2/3 of mag. ×300.

enough to warrant resection.[8] At times one will perceive the mainly exudative form, with innumerable organisms in the alveoli. At others, caseous or fibrotic lesions or combinations of the two are noted. Tumor-like isolated lesions are rarely observed in blastomycosis. We found the dry, productive type of pleuritis seldom missing over blastomycotic pulmonary foci.[39] In the lymph nodes the picture is quite variable. Small tubercles with isolated giant cells, large areas of caseation, and extensive fibrosis with heavy anthracosis will all be found. In fibrotic lesions it is almost useless to look for organisms.[39,40]

Blastomycosis almost never attacks the gastrointestinal or female genital tract. In the male genital tract, however, blastomycosis is common, especially in the prostate.

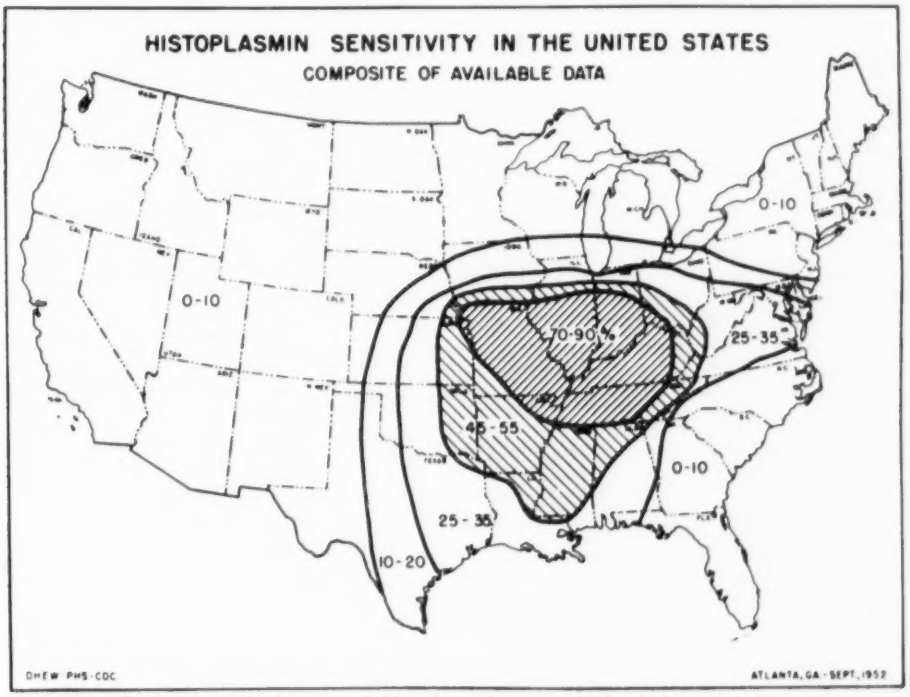


Fig. 5.—In the endemic area of histoplasmosis up to 90% of the population react to intradermal skin tests with histoplasmin. A disease which is so common in a given population, even if asymptomatic or subclinical in the overwhelming majority of infected persons, must be considered in differential diagnosis of all chronic disorders and should be kept in mind as a possibility even in acute febrile diseases, especially in children. Reproduced from article by J. Schwarz and M. L. Furcolow in the *American Journal of Clinical Pathology* (71:261, 1955), published by Williams & Wilkins Company, Baltimore.

Abscesses teeming with organisms are the rule, and we have even seen acute urinary retention caused by blastomycotic prostatitis. Fungating testicular lesions and cystitis have likewise come to our attention.

Bones are frequently involved in blastomycosis. Every granulomatous osteomyelitis should, therefore, be examined for organisms, and not simply labeled "granulomatous" or "tuberculous" without study of special stains.

We have even observed blastomycosis in a biopsy specimen of brain from a case operated on for "tumor."

Eye involvement has been observed, although rarely.[7]

Blastomycosis in dogs is not uncommon in our material. The pathology is almost identical with that in man.[35]

Histoplasmosis

Histoplasmosis is very common in the endemic area. Most of the cases are subclinical and asymptomatic, but it stands to reason that any disorder producing up to 90% skin reactivity in a population would have great differential diagnostic importance.

Fig. 6.—Focal caseated lesions with concentric structure are found with increasing frequency in the lung as the anatomical substrate of the radiologic finding of a "coin" lesion. Special stains can, in many instances, clarify the etiology, even if sputum cultures had been negative. See Figure 7.

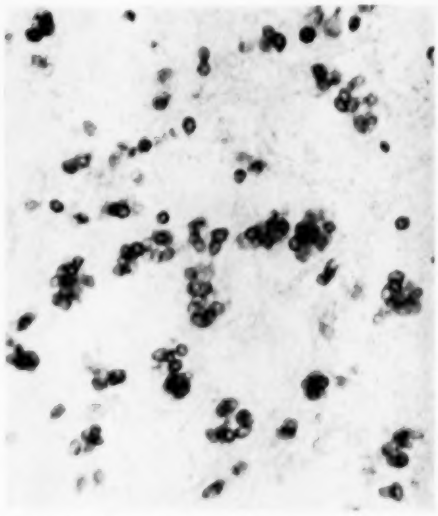


Fig. 7.—Clusters of uniform, small yeast cells are found in the center of caseated, or even calcified, lesions of "histoplasmomas." Grocott stain; reduced to 2/3 of mag. × 950.

Southwestern Ohio, Tennessee, Kentucky, Indiana, Missouri, southern Illinois, eastern Kansas, the southern portion of Iowa, and the northern part of Arkansas show the highest figures of positive reactions to histoplasmin.[42]

Histoplasmosis starts in the lungs. Numerous calcifications in chest x-rays of patients living in the endemic are due to this infection.[47] H. capsulatum can be demonstrated by appropriate staining technique in tissues and smears. In the lung, the disease generally stops with the development of a (later calcified) primary complex, but exceptionally two forms develop which may become surgical problems. The first is the so-called "tuberculoma." This is a sharply circumscribed, generally encapsulated tumor-like lesion, which is 1 to 3 cm. or more in diameter and which after gross sectioning shows an unmistakably concentric lamination.[31] Segmental resection is all that is needed to remove such a lesion; but since often lymphatic spread surrounds the main lesion it is very desirable to remove generous pieces of "normal" tissue with the granuloma. The coin lesion is grayish, caseated, and often calcified in the center,

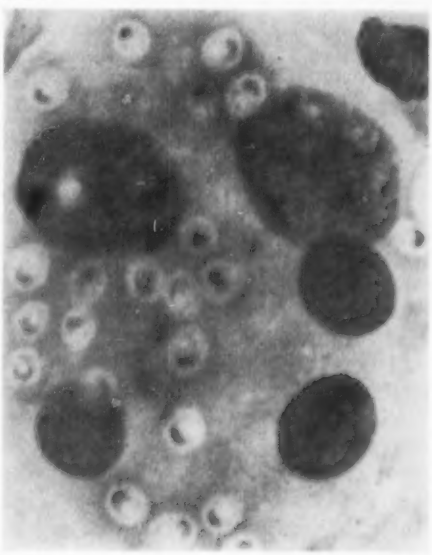
Fig. 8.—Cavitary histoplasmosis. In this type of lesion the sputum culture is generally positive for H. capsulatum. The radiologic and gross appearance may be indistinguishable from cavitary disease in tuberculosis, actinomycosis, or other mycoses.

even if the calcium is not demonstrable on x-rays. It is extremely important to culture from the center of the lesion, because this is the only part in which organisms are found regularly.

The second pulmonary lesion which may be attacked surgically is cavitary histoplasmosis. Cavities are apparently much commoner than was believed even a very short time ago.[13,14,51] The cavities thus far observed in our limited experience are indistinguishable radiologically, and upon gross inspection of the resected specimen, from the ones seen in tuberculosis. They may have thick, fibrous walls and rather smooth lining, and bronchi and vessels may cross the lumen. They can be small and irregular and represent holes which develop after focal necrosis of a rather acute pneumonic process. Only the demonstration of organisms can settle the diagnosis. In caseation necrosis and in the center of calcified nodules, H. capsulatum can be best demonstrated with the Gridley or the Grocott stain, but the organism can hardly ever be identified with the hematoxylin and eosin stain. It is our experience that these two methods are much superior to the, older, PAS method. Without culture the results will often be little more than an educated guess. Mycobacterium, Cryptococcus, Blastomyces, and Histoplasma have been found in the same lung,[23,26,30,36] the diagnosis of which could never be realized except through culture methods.

The next major group of diagnostic material comes from lymph nodes. The ease of morphological diagnosis of histoplasmic lymphadenitis varies. Sometimes numerous intracellular organisms are found in swollen histiocytes. Sometimes granulomatous lesions with few yeast cells demonstrable are seen, and often no organisms can be visualized in spite of suggestive morphology, such as caseation or histiocytic proliferation. Sometimes organisms can be found outside the morphologically suspicious area, and they must be verified by special staining. Debris is so common in the center of lymph

Fig. 9.—Tissue press from ulcer on oral aspect of lip. The ovoid organisms of H. capsulatum are surrounded by a halo and have accumulations of chromatin on one pole. The patient was a 78-year-old white man, described in chapter on histoplasmosis. Wright stain; reduced to 2/3 of mag. × 2300.



follicles that it has frequently been misdiagnosed as Histoplasma.[9,33,53]

Notoriously, organisms of the Leishmania group are morphologically similar to Histoplasma, and even with the special stains it is difficult to differentiate in tissues Leishmania from Histoplasma. The kinetoblast in the Leishman bodies is not as easily visible in tissues as it is in smears.[10]

Biopsy tissue from the lips or pharyngolaryngeal mucosae sometimes shows Histoplasma. The inflammatory response may be rather meager, but in a few histiocytes organisms may be suspected with hematoxylin-eosin staining and demonstrated with the special stain. Histoplasmosis in the mouth occurs in the form of shallow ulcers with indurated borders on the tongue or in the form of whitish nodules under the labial mucosa: It may even appear as polypoid tumor-like infiltrates, especially on the lips. Perforation of the nasal septum due to ulcerative histoplasmosis occurs, and in the larynx polypoid vegetations or ulcers have been seen. Local excision or chemical destruction may be sufficient to arrest the local process. This, as previously discussed with respect to blastomycosis, will be effective only if the pulmonary lesion has become arrested.

A 78-year-old white man was admitted to the hospital on Sept. 13, 1955, with a six-week history of nodules on the inner surface of his lower lip, on the upper lip, and on the buccal surface of the cheek. He had noted a 10 lb. (4.5 kg.) weight loss during this period. The lesions were nodular, nontender, and not fluctuant. Lesions developed on the tongue while he was in the hospital. His histoplasmin skin test was positive. Biopsy of the lesion of his lip revealed histoplasmosis on section and culture. The patient was given local nystatin (Mycostatin), whereupon the lesions cleared. The patient died shortly after, of a coronary occlusion. No active histoplasmosis was found in the lungs or any where else.

In disseminated cases we have seen skin rashes which microscopically showed minimal round-cell infiltration and organisms in the dermis.[45] Blood and bone-marrow smears, tissue press from lymph nodes, and other excised tissues can be of great help in the diagnosis. A simple Wright stain brings out the organisms very clearly. They are found mostly in monocytes, occasionally in polymorphonuclear leukocytes, but never in red cells. The organism appears round to slightly ovoid, often with an accumulation of chromatin on one pole. The halo is clearly visible. There seems to be increasing evidence, including that from electromicroscopy, that the halo does not represent a true capsule.[37] In overwhelming cases bone marrow and blood smears are usually positive on smear and/or culture, the bone marrow more frequently than the peripheral blood. Even in such cases blood studies have a higher rate of positivity in children than in adults.[34]

Bronchial biopsies can sometimes be diagnostic for histoplasmosis but do not show any unusual pictures. The liver is almost always involved in disseminated histoplasmosis, and liver biopsy specimens represent a very desirable material both for microscopy and for culture. Histoplasmic ulcers occur in all parts of the gastrointestinal tract.[11,21] The ulcers are often multiple, and they have elevated borders and/or may be shallow. We did see, especially in children, profuse intestinal hemorrhage originating from hundreds of such ulcerations.[45] The mesenteric lymph nodes in such cases may be considerably enlarged and often show granulomatous response and necrosis. Reaction in the serosa may be seen only in deep-penetrating ulcers, and the appendix may be involved in such patients. Isolated appendicitis caused by Histoplasma rarely occurs. Huge histiocytes filled with organisms are present in such cases: debris in the follicles should not be mistaken for organisms.[9,33]

Coccidioidomycosis

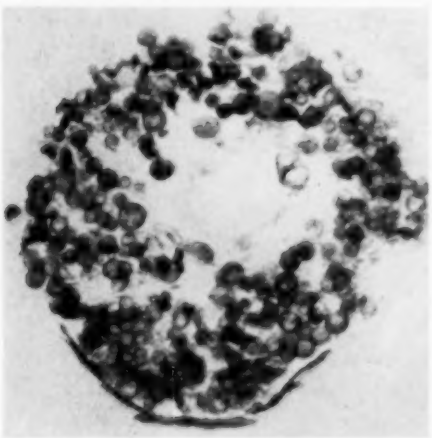
Coccidioidomycosis bears close pathogenetic resemblance to blastomycosis and histoplasmosis in that all are almost always primarily pulmonary diseases.

The disease is endemic in the southwestern part of the United States, with the highest frequency of incidence in the San Joaquin

Valley, in California. However, the disease has also been found endemically in lower California, in parts of Arizona and Texas, and in New Mexico. It has not, however, been found east of the Mississippi River.[11]

The disease is most frequently asymptomatic. A diagnosis of coccidioidomycosis in tissue sections is often easier because of the size of the causative organism. In tissues C. immitis produces a round body, the "spherule," measuring from 10μ to 80μ, but rarely as high as 265μ, in diameter. This spherule may have a very thick wall and, before it ruptures, usually contains numerous endospores. The endospores are formed by cleavage, and anywhere from two to several hundred may be observed in an intact spherule. The size of the endospores varies inversely with their number. Once the spherule ruptures, the endospores are liberated, and each endospore develops into another spherule. The endospores are round or ovoid and are smooth, quite variable in size, and hence capable of being confused with B. dermatitidis, H. capsulatum, C. neoformans, and Candida. For this reason the diagnosis of coccidioidomycosis can not be made morphologically when only endospores are seen. The diagnosis of coccidioidomycosis can, however, be strongly suspected if clusters of endospores are seen, which suggest the existence of a recently ruptured spherule. The thin wall of the endospores precludes the suggestion of B. dermatitidis, as does the absence of budding. The absence of a capsule about the endospores discourages the assumption of C. neoformans. The larger size of the endospore, as a rule, speaks against H. capsulatum and Candida. The collapsed spherule loses its form, is sometimes fragmented, and may show the most unlikely of shapes. But the Gridley stain brings out the selective redness of the wall of the spherule, even in old calcified or chronic lesions.

Fig. 10.—The spherule of C. immitis is large (10μ to 260μ) and, when filled with endospores, very typical. Notice variation in the size of endospores. Gridley stain; reduced to 64% of mag. × 600.



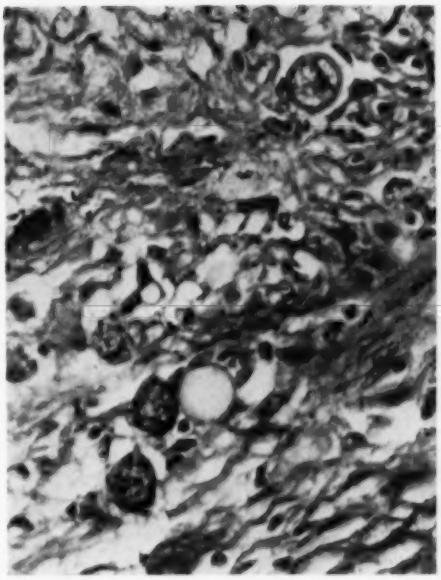


Fig. 11.—Spherules with thick walls and numerous endospores are scattered throughout the granulation tissue. At least one spherule is empty. Coccidioidomycosis of the lung. Hematoxylin and eosin; reduced to 2/3 of mag. × 600.

The important pulmonary lesions of coccidioidomycosis most frequently seen are thin-walled cavities and "tuberculomas." This latter entity, better called a coccidioidoma, is grossly difficult to differentiate from other solitary granulomas of different etiology.[55] Microscopically, a typical granuloma is seen. Caseation is apt to be prominent. According to Forbus,[12] coccidioidomycosis, more than any other fungus

disease, tends to produce extensive caseation. The concentric structure is as prominent in the coccidioidoma as in similar lesions of tuberculosis and histoplasmosis. The pulmonary cavity is characteristically quite thin-walled. In all these lesions of the lungs the positive diagnosis can be made only upon observation of the spherule and endospores. If searched for, hypal elements can be observed in such cavities.[32]

The pathology in the lymph nodes is in no way specific, but caseation or calcification may be found.[48]

Microscopically, the skin lesions can resemble blastomycosis where pseudoepitheliomatous proliferation is found along with small abscesses. In such instances, the geographic history of the case, the skin test, the serology, and, of course, demonstration of the organism will help to establish the correct diagnosis. In other instances the skin lesions are ulcerative, and the presence of epithelioid tubercles in such a lesion is suggestive only of a specific granulomatous disease, emphasizing the importance of routine staining for fungi by one of the special techniques. The number of diagnoses reading "granuloma, cause undetermined" can be decreased to a great extent by the use of special staining procedures, prolonged search, and familiarity with the morphology of fungi.

Erythema nodosum and erythema multiforme are observed fairly often, especially in females, in early coccidioidomycotic infection and may be the only manifestation of the infection.

In the disseminated disease any organ system may be involved. The lesions in the organs are not always specific but are, for the most part, granulomatous in nature. Giant cells are seen, and caseation may be noted. The finding of the spherules is diagnostic.

Such a disseminated disease may be rapidly progressive and fatal or may take years to run its course. In the latter type of illness, lesions may be found in bone, joints, genitourinary tract, brain, etc.[2,5,41]

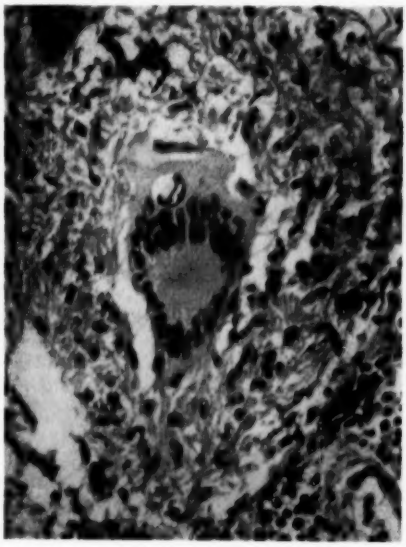
Coexistence of coccidioidomycosis and tuberculosis can add considerably to the already existing diagnostic difficulties.[46]

Cryptococcosis

Cryptococcosis is usually recognized clinically as a chronic recurrent meningitis, in which form it is almost invariably fatal. It is felt, however, that the central nervous system manifestations result from the hematogenous dissemination from a primary pulmonary infection. Less commonly, other secondary lesions may be seen in almost any organ, including skin, abdominal viscera, and bone.[29]

The organism causing the disease, C. neoformans, is a yeast-like organism, which grows readily on most laboratory media. The yeast cell is surrounded by a capsule containing a mucopolysaccharide, which may be as much as 40μ to 50μ in diameter. Budding cells are a common sight. Occasionally the capsule is narrow or absent,

Fig. 12.—Epithelioid-cell tubercles can be seen in most deep mycoses. Here a collapsed spherule of C. immitis within a multinucleated giant cell reveals the true nature of the lesion. Hematoxylin and eosin; ×170. Reproduced from article by M. Straub and J. Schwarz (26:998-1009, 1956), *American Journal of Clinical Pathology*, Williams & Wilkins Company, Baltimore.



leading to confusion with H. capsulatum, B. dermatitidis, or B. brasiliensis. The organisms can be easily identified if an India ink mount is made of liquid material or sediment containing the organism. Characteristically there are seen many circular to ovoid halos around the yeast cells, in which no India ink is present; these represent the capsule.

In tissue sections the organism and its surrounding capsule may be quite evident without any special stain being used. However, there are instances in which the number of organisms is small or the size of their surrounding capsule is not striking, in which instances the use of special stains is extremely helpful. The Bauer, PAS, Gridley, and Grocott silver stains are all useful, but the one which, in this instance, produces the most dramatic result is the mucicarmine stain.

The pathological response to the organism varies greatly, from practically no reaction to a granulomatous type of response. In the lungs extreme variations of both these types of reaction may be observed. Solitary active or arrested lesions may be removed, which are often subpleural [3,20] and may vary considerably in size. The "coin lesions" so commonly seen in histoplasmosis and coccidioidomycosis are rare in cryptococcosis.[55] Cavitation in the lung due to C. neoformans is quite unusual. Caseation within the lungs is not common, and the regional lymph nodes may be involved with a similar process. We have seen calcification in mediastinal lymph nodes from which cryptococci were cultured and demonstrated in tissue sections.

On the other hand, the pulmonary lesions may be a large collection of organisms with very little reaction about them. This collection may achieve markedly large size and on gross section give a gelatinous appearance. This latter characteristic is due to accumulation of capsular substance. Any variation of these two patterns may be observed. In calcified lesions it may be impossible to demonstrate the capsule, and a positive identification becomes impossible.

The meningitis in torulosis is usually patchy, with the main concentration of exudate around the base of the brain. The spinal fluid shows a moderate pleocytosis, with a count in the neighborhood of 200 per cubic millimeter, though higher cell counts may, in rare instances, be observed. There is moderate increase in protein and moderate decrease in the spinal fluid sugar. The cells seen are usually lymphocytes. The organism itself may be found in the spinal fluid and may actually be confused with lymphocytes in the counting chamber. An India ink preparation of the spinal fluid may well give the answer.

Involvement of the brain substance itself occurs with marked frequency in cases of meningitis. Once again the disparity in types of reaction is noted. Large collections of organisms may be found in cyst-like cavities, varying in size from small "bubble-like" to large cysts. These characteristically are gelatinous on section and microscopically show little surrounding cellular reaction. However, there may also be observed a marked granulomatous response with pronounced glial reaction. In such instances solitary lesions may be found which have space-occupying characteristics and may lead to resection ostensibly for tumor. In such instances careful observation, making use of special stains, will reveal the true nature of the disease.

Infrequently, lesions may be submitted for examination from skin, bone, and internal abdominal organs: The use of special stains, particularly the mucicarmine stain, will help greatly in definitive diagnosis of such lesions.

C. neoformans has been found more frequently than any other of the deep fungi in the tissues of patients with malignant lymphoma. This is especially true in Hodgkin's disease. Cryptococcosis has also been noted simultaneously with sarcoidosis.[29] It seems most unlikely that these fungi are the cause of these diseases. One explanation which seems reasonable is that, since the reticuloendothelial system is involved in all these diseases, its effectiveness in body de-

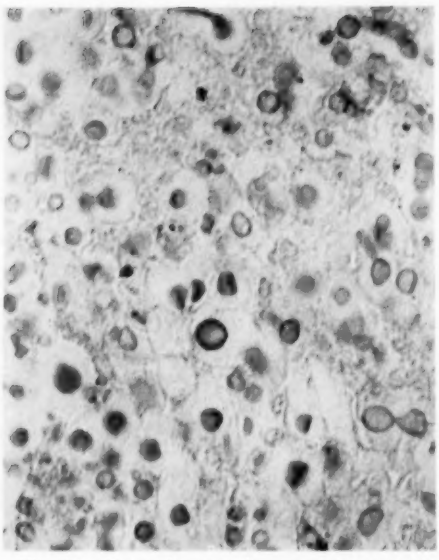


Fig. 13.—C. neoformans is a round yeast surrounded by a huge capsule. The tissue response is often minimal. Cryptococcus in lymph node. Hematoxylin and eosin; reduced to 2/3 of mag. × 950.

fense is decreased and the fungi are therefore more able to invade and infect the involved organs. The full understanding of these phenomena has yet to be reached.

Intrapulmonary Fungus Balls

Finally, an entity of questionable significance should be mentioned. In several instances there have been found within pulmonary cavities or cysts, masses of hyphae and spores which have been interpreted as either Aspergillus or Candida. In most instances cultural identification has been unsuccessful.

Levin [27] recently reported four cases, three of which had pathologic corroboration. The pathology of these three cases was essentially the same. The cavities were in no way different from the usual chronic pulmonary abscess due to aspiration, infected cysts, etc. There was no evidence of mycelium within the cavity walls or the adjacent pulmonary parenchyma. These cavities were solitary and were unicameral. Within the cavities was noted a freely movable mass, which was smoothly rounded, ovoid, and friable. On microscopic examination this showed a dense meshwork of intertwined hyphae, along with degenerated blood and epithelial elements.

The material from Levin's [27] cases was sterile, as was the material from other reports.[7,24] Yesner [54] and Gerstl and associates [16] reported two cases in which the culture yielded Aspergillus fumigatus.

Several other fungus diseases of lower frequency must be mentioned for completeness. Actinomycosis is the commonest of these, followed by sporotrichosis. Nocardiosis, moniliasis (pulmonary), mucormycosis, aspergillosis, geotrichosis, chromoblastomycosis, etc., are only rarely seen.

Cultural diagnosis may be materially aided if information obtained from clinical, radiological, and morphological examinations is used to direct mycologic investigation. For example, the presence of a fistula without lymph node enlargement suggests infection with Actinomyces bovis, and the necessary "anaerobic" culture would be requested. Another case may demonstrate a positive skin reaction to coccidioidin and give a history of residence in the southwestern desert. This would indicate the possibility of C. immitis, and intratesticular injection of culture material into a guinea pig would follow.

Biopsy is the most important single procedure in making specific mycologic diagnosis, because the material may be used for histologic examination, making use of special stains and culture. It should be added that laboratories using special stains for fungi infrequently should make use of known positive sections as controls.

Summary

Some of the deep fungi can produce diffuse granulomatous disease in man and lower animals which may involve many organs—North American blastomycosis, histoplasmosis, coccidioidomycosis, and cryptococcosis. The lung is the common

portal of entrance of the four diseases under discussion, and all other localizations, including the skin lesions, are generally secondary.

In North American blastomycosis and, to a less degree, in coccidioidomycosis, pseudoepitheliomatous hyperplasia with microabscesses is a typical finding, which should call attention to a mycotic etiology of cutaneous lesions.

The recognition of fungi in tissue is greatly facilitated by the use of special stains. The mucicarmine stain is recommended for demonstration of C. neoformans, the Gridley stain for all fungi, and the Grocott stain especially for photographic purposes.

The index of suspicion is in direct proportion to the finding of fungus diseases. The biopsy is an ideal tool for rapid diagnosis and the most important single procedure, especially if the material is used for histologic and cultural studies.

The Jewish Hospital Association (29).

REFERENCES

1. Alfred, K. S., and Harbin, M.: Blastomycosis of Bone: Report of Case, J. Bone & Joint Surg. 32-A:887-892, 1950.

2. Amromin, G., and Blumenfeld, C. M.: Coccidioidomycosis of Epididymis: Report of 2 Cases, California Med. 78:136-138, 1953.

3. Baker, R. D., and Haugen, R. K.: Tissue Changes and Tissue Diagnosis in Cryptococcosis: A Study of 26 Cases, Am. J. Clin. Path. 25:14-24, 1955.

4. Bauer, H.: Mikroskopisch-chemischer Nachweis von Glykogen und einigen anderen Polysacchariden, Ztschr. mikr.-anat. Forsch. 33:143-160, 1933.

5. Bennett, H. D.; Milder, J. W., and Baker, L. A.: Coccidioidomycosis—Possible Fomite Transmission, J. Lab. & Clin. Med. 43:633-636, 1954.

6. Binford, C. H.: Histoplasmosis: Tissue Reaction and Morphologic Variations of the Fungus, Am. J. Clin. Path. 25:25-36, 1955.

7. Cassady, J. V.: Uveal Blastomycosis, Arch. Ophth. 35:84-97, 1946.

8. Chick, E. W.; Sutliff, W. D.; Rakich, J. H., and Furcolow, M. L.: Epidemiological Aspects of Cases of Blastomycosis Admitted to Memphis, Tennessee, Hospitals During the Period 1922-1954: A Review of 86 Cases, Am. J. M. Sc. 231:253-262, 1956.

9. Collins, D. C.: Histoplasma Capsulatum: The Principal Cause for Mesenteric Lymphadenitis in Juveniles, Mississippi Valley M. J. 47:146-152, 1955.

10. Finneman, H. H., and Hall, W. H.: Chronic Pharyngeal and Laryngeal Histoplasmosis Successfully Treated with Ethyl Vanillate, Minnesota Med. 36:249-252, 1953.

11. Fitzpatrick, T. J., and Neiman, B. H.: Histoplasma Capsulatum Infection Associated with Gastric Ulcer and Fatal Hemorrhage, A. M. A. Arch. Int. Med. 91:49-55, 1953.

12. Forbus, W. D., and Bestebreurtje, A. M.: Coccidioidomycosis: Study of 95 Cases of the Disseminated Type with Special Reference to the Pathogenesis of the Disease, Mil. Surgeon 99: 653-719, 1946.

13. Forsee, J. H.; Puckett, T. F., and Hagman, F. E.: Surgical Considerations in Focalized Pulmonary Histoplasmosis, J. Thoracic Surg. 26:131-139, 1953.

14. Furcolow, M. L., and Brasher, C. A.: Chronic Progressive (Cavitary) Histoplasmosis as a Problem in a Tuberculosis Sanatorium, Am. Rev. Tuberc. 73:609-619, 1956.

15. Georg, L. K.; Ajello, L., and Papageorge, C.: Use of Cycloheximide in the Selective Isolation of Fungi Pathogenic to Man, J. Lab. & Clin. Med. 44:422-428, 1954.

16. Gerstl, B.; Weidman, W. H., and Abbott, V. N.: Pulmonary Aspergillosis: Report of 2 Cases, Ann. Int. Med. 28:662-671, 1948.

17. Graves, C. L., and Millman, M.: Lobectomy for Fungous Abscess of the Lung: Effect of Penicillin, J. Thoracic Surg. 22:202-207, 1951.

18. Gridley, M. F.: A Stain for Fungi in Tissue Sections, Am. J. Clin. Path. 23:303-307, 1953.

19. Grocott, R. G.: A Stain for Fungi in Tissue Sections and Smears Using Gomori's Methenamine-Silver Nitrate Technic, Am. J. Clin. Path. 25:975-979, 1955.

20. Haugen, R. K., and Baker, R. D.: The Pulmonary Lesions in Cryptococcosis with Special Reference to Subpleural Nodules, Am. J. Clin. Path. 24:1381-1390, 1954.

21. Henderson, R. G.; Pinkerton, H., and Moore, L. T.: Histoplasma Capsulatum as Cause of Chronic Ulcerative Enteritis, J. A. M. A. 118: 885-889, 1942.

22. Hotchkiss, R. D.: A Microchemical Reaction Resulting in the Staining of Polysaccharide Structures in Fixed Tissue Preparations, Arch. Biochem. 16:131-141, 1948.

23. Hughes, E. A.; Whitaker, H. W.; Lowry, C. E.; Polk, J. W.; Foley, F. E., and Fox, J. R.:

Resection for Mycotic Pulmonary Disease. Dis. Chest 25:334-349, 1954.

24. Humphill, R. A.: Mycotic Lung Infection, Am. J. Med. 1:708-709, 1946.

25. Kligman, A. M.; Mescon, H., and DeLamater, E. D.: The Hotchkiss-McManus Stain for the Histopathologic Diagnosis of Fungus Diseases, Am. J. Clin. Path. 21:86-91, 1951.

26. Layton, J. M.; McKee, A. R., and Stamler, F. W.: Dual Infection with B. Dermatitidis and H. Capsulatum: Report of Fatal Case in Man, Am. J. Clin. Path. 23:904-913, 1953.

27. Levin, E. J.: Pulmonary Intracavitary Fungus Ball, Radiology 66:9-16, 1956.

28. Levitas, J. R., and Baum, G. L.: Surgical Aspects of Blastomycosis, Surgery 33:93-101, 1953.

29. Littman, M. L., and Zimmerman, L. E.: Cryptococcosis: Torulosis or European Blastomycosis, New York, Grune & Stratton, Inc., 1956.

30. Mider, G. B.; Smith, F. D., and Bray, W. E., Jr.: Systemic Infection with C. Neoformans and H. Capsulatum in the Same Patient, Arch. Path. 43:102-110, 1947.

31. Puckett, T. F.: Pulmonary Histoplasmosis: A Study of 21 Cases with Identification of H. Capsulatum in Resected Lesions, Am. Rev. Tuberc. 67:453-476, 1953.

32. Puckett, T. E.: Hyphae of Coccidiodes Immitis in Tissues of the Human Host, Am. Rev. Tuberc. 70:320-327, 1954.

33. Raftery, A.; Trafas, P. C., and McClure, R. D.: Histoplasmosis: A Common Cause of Appendicitis and Mesenteric Adenitis, Ann. Surg. 132:720-728, 1950.

34. Rohn, R. J., and Bon, W. H.: The Value of Routine Bone Marrow Culture for H. Capsulatum in Pediatric Hematology, Blood 8:329-335, 1953.

35. Robbins, E. S.: North American Blastomycosis in the Dog, J. Am. Vet. M. A. 125:391-398, 1954.

36. Rodger, R. C.; Terry, L. L., and Binford, C. H.: Histoplasmosis, Cryptococcosis, and Tuberculosis Complicating Hodgkin's Disease, Am. J. Clin. Path. 21:153-157, 1951.

37. Salvin, S. B.: Personal communication to the authors.

38. Schwarz, J.: Giant Forms of H. Capsulatum in Tissue Explants, Am. J. Clin. Path. 23: 898-903, 1953.

39. Schwarz, J., and Baum, G. L.: Blastomycosis, Am. J. Clin. Path. 21:999-1029, 1951.

40. Schwarz, J., and Baum, G. L.: North American Blastomycosis, Docum. med. geog. et trop. 5:29-41, 1953.

41. Schwarz, J., and Baum, G. L.: Coccidioidomycosis: A Review, Am. J. M. Sc. 230:82-97, 1955.

42. Schwarz, J., and Furcolow, M. L.: Some Epidemiologic Factors and Diagnostic Tests in Blastomycosis, Coccidioidomycosis, and Histoplasmosis, Am. J. Clin. Path. 25:261-265, 1955.

43. Schwarz, J., and Goldman, L.: Epidemiological Study of North American Blastomycosis, A. M. A. Arch. Dermat. 71:84-88, 1955.

44. Shefts, L. M.; Terrill, A. A., and Swindell, H.: Scalene Node Biopsy, Am. Rev. Tuberc. 68: 505-522, 1953.

45. Silverman, F. N.; Schwarz, J.; Lahey, M. E., and Carson, R. P.: Histoplasmosis, Am. J. Med. 19:410-459, 1955.

46. Stein, H. F.: Coexisting Pulmonary Coccidioidomycosis and Tuberculosis, Am. Rev. Tuberc. 67:477-489, 1953.

47. Straub, M., and Schwarz, J.: The Healed Primary Complex in Histoplasmosis, Am. J. Clin. Path. 25:727-741, 1955.

48. Straub, M., and Schwarz, J.: Primary Pulmonary Arrested Lesions of Coccidioidomycosis and Histoplasmosis in Tucson, Arizona, Am. J. Clin. Path., 26:998-1009, 1956.

49. Weed, L. A.: Large and Small Forms of Blastomyces and Histoplasma, Am. J. Clin. Path. 23:921-923, 1953.

50. Weed, L. A., and Parkhill, E. M.: The Diagnosis of Ulcerative Diseases of the Mouth and Pharynx, Am. J. Clin. Path. 18:130-140, 1948.

51. White, F. C.: Chronic Pulmonary Disease in Histoplasmosis Reactors, Am. Rev. Tuberc. 72: 274-296, 1955.

52. Wilson, J. W.; Cawley, E. P.; Weidman, F. D., and Gilmer, W. S.: Primary Cutaneous North American Blastomycosis, A. M. A. Arch. Dermat. 71:39-45, 1955.

53. Winkel, W. E. F.; Collier, W. A., and Hillers, A. A.: Histoplasma Findings in Menstrual Disturbance, Docum. med. geog. et trop. 5:215-219, 1953.

54. Yesner, R., and Hurwitz, A.: A Report of a Case of Localized Bronchopulmonary Aspergillosis Successfully Treated by Surgery, J. Thoracic Surg. 20:310-314, 1950.

55. Zimmerman, L. E.: The Demonstration of Histoplasma and Coccidioides in So-Called Tuberculomas of the Lung: Preliminary Report of 35 Cases, A. M. A. Arch. Int. Med. 94:690-699, 1954.

Postoperative Respiratory Acidosis

WILL C. SEALY, M.D.; W. GLENN YOUNG Jr., M.D., and JOHN B. HICKAM, M.D., Durham, N. C.

Respiratory acidosis developing in emphysematous patients from impaired pulmonary ventilation is well known.[2-4] Patients with normal lungs undergoing surgery have been observed to develop carbon dioxide retention from the failure of the anesthetist to maintain adequate ventilation.[1,6] In the immediate postoperative period, it is not unexpected that instances of serious respiratory acidosis are found. This may be an exacerbation of a chronic acidosis in an emphysematous patient, or it may be acute, from interference with ventilation by events related to the operation. At Duke Hospital two postoperative patients have been studied with the two types of respiratory acidosis. An account of difficulties in recognition and the methods of treatment of this condition is outlined in this report.

Report of Cases

CASE 1.—A 61-year-old white man, a conservation engineer, was admitted to Duke Hospital on Oct. 6, 1954, complaining of recurrent small hemoptyses, of eight weeks' duration. There was no history of previous respiratory complaints.

On physical examination, the blood pressure was 125/75 and the pulse rate was 80 per minute and regular. Examination of the chest showed evidence of mediastinal shift to the left, but no rales or expiratory wheezes were noted.

On admission, the hemoglobin was 13.7 gm. per 100 cc. and the red cell count 4,610,000. The white cell count and the urine were normal. The electrocardiogram was within normal limits. Atelectasis of the left lower lobe was present on x-ray study. Bronchoscopy revealed carcinoma of the left lower-lobe bronchus.

On Oct. 11, a left pneumonectomy was done, using for anesthesia 500 mg. of thiopental (Pentothal) sodium, ethylene, ether, and 285 mg. of succinylcholine (Anectine) chloride U. S. P., with controlled respiration. The patient's immediate postoperative course was stormy. Four hours after operation his pulse became grossly irregular, due to auricular flutter. This responded to rapid digitalization.

On the first postoperative day, he was noted to be slightly disoriented, and chest examination showed expiratory wheezes, which did not disappear in spite of repeated administration of aminophylline, ephedrine, and inhalations of isoproterenol U. S. P. (Isuprel). On the seventh postoperative day he became more confused. At this time he was given 20 units of corticotropin intravenously over an 18-hour period. There was no improvement in his condition. On the eighth postoperative day he was given another 20 units of corticotropin. On the ninth day he was completely disoriented, and the signs of bronchospasm were more intense. Because of increasing dyspnea and thick bronchial secretions, a tracheotomy was performed. He was then placed in a Drinker respirator, followed by the administration of 100 mg. of hydrocortisone intravenously. In four hours, the expiratory wheezes disappeared, and there was noticeable improvement in his sensorium. On the 12th day he was removed from the respirator, and on the 14th postoperative day the tracheotomy tube was removed. Table 1 summarizes the clinical course and laboratory findings in this case. The patient was able to return to work in two months after discharge from the hospital.

CASE 2.—A 36-year-old storekeeper was admitted to Duke Hospital because of severe dyspnea for the past eight months. After recurrent bouts of pneumonia in 1944, he noted for the first time dyspnea on exertion. This had been slowly progressive until the sudden increase at the onset of his present illness. Four days before admission an x-ray film revealed a partial left pneumothorax.

He lost his left lower extremity in a train accident in 1935 and had worn a prosthesis to the midthigh since then.

Physical examination revealed the blood pressure to be 130/84. Breath sounds could not be heard over the left chest. He had a healed left midthigh amputation stump.

Laboratory studies on admission revealed the hemoglobin to be 16.5 gm. per 100 cc., with the white blood cell count and urine within the limits of normal. Pulmonary function studies revealed the maximum breathing capacity to be 20.2 liters

Submitted for publication March 26, 1957.

Division of Thoracic Surgery and Department of Medicine, Duke University School of Medicine.

TABLE 1 *(Case 1).—Respiratory Acidosis in Man Aged 61 Following Left Pneumonectomy for Carcinoma of Left Lower-Lobe Bronchus*

Days After Operation	pCO_2 Mm/Hg	Arterial Blood		Comment
		pH	% O_2 Saturation	
2				Expiratory wheezes, mild mental cloudiness
7	67.4	7.38	74.0	Marked mental confusion, expiratory wheezes, corticotropin, I. V., not effective
9	96.7	7.16		Completely disoriented, marked air hunger; tracheotomy, Drinker respirator, cortisone, I. V.; marked improvement in 4 hr.
10	77.5	7.30	95.3	In respirator on 80% O_2
10	77.5	7.30	95.3	Out of respirator, on 80% O_2
12				Out of respirator; no expiratory wheezes, sensorium clear
14	61.5	7.41	87.8	In chair; tracheotomy tube removed; no expiratory wheezes

per minute, his predicted normal being 150 liters per minute. At rest his arterial oxygen saturation was 81.5%, with a carbon-dioxide tension of 65 mm. Hg.

On Nov. 15, 1951, the patient had a left thoracotomy, using ether and nitrous oxide anesthesia. The left lung was more than 50% collapsed. The upper lobe was replaced with very large emphysematous cysts, and the lower lobe was almost completely collapsed and encapsulated with a very thick fibrin envelope. The lower lobe was freed by removal of the visceral pleural membrane, so that it expanded completely. No air leak was found, and none of the cysts were excised. On return to the ward, the patient was given oxygen, 6 liters per minute, by nasal catheter. In three hours he was awake. Nine hours after operation, he was observed to be perspiring profusely. His blood pressure had dropped from 120/80 to 84/28. After tracheal aspiration and coughing, the pressure increased to 140/100. Twelve hours later, he was again noted to be sweating profusely, and his blood pressure was 100/80. Twenty-four hours after operation, he was completely unresponsive, with a blood pressure of 90/60. His color was good, and respirations were 12 per minute. Oxygen administration, which had been continued since operation, was then stopped. In the next hour he became responsive and his blood pressure was stabilized at 120/80. Table 2 summarizes his clinical course and blood-gas studies. This patient did well for two years after operation, when he died, at home, of an acute respiratory infection.

Comment

Because the diffusibility of carbon dioxide is so much greater than that of oxygen, the former is retained in toxic amounts only when there is an unusual impairment of ventilation, such as might develop during surgery. In the immediate postoperative period, one might expect respiratory acidosis to occur, for factors important in its genesis, such as a painful chest incision, retained tracheobroncial secretions, bronchospasm, and the depressant effect of drugs, may all be present. The factors just listed would lead to acute respiratory acidosis. It is possible, however, to have an acute exacerbation of chronic respiratory acidosis after surgery directly related to postoperative oxygen therapy, as exemplified by Case 2. In the latter case, emphysema resulted in long-standing carbon dioxide retention, which, in turn, caused the respiratory center to become insensitive to high blood levels of carbon dioxide, shifting the automatic control of respiration to the chemoreceptor response to hypoxia. Such patients, of course, have hypoxia as well as hypercapnia. It is obvious, then, that the continuous adminis-

TABLE 2 (Case 2).—*Respiratory Acidosis in Men Aged 45 After Right Thoracotomy and Decortication of Right Lung: Diagnosis: Emphysema, Pneumothorax, Fibrothorax, and Chronic Respiratory Acidosis*

Time	pCO_2 Mm/Hg	Arterial Blood		Comment
		pH	% O_2 Saturation	
Preoperative	65	7.33	82	
First postoperative day on oxygen	109	6.97	99	Unconscious; O_2 by nasal catheter; 6 liters per min. past 24 hr.
First postoperative day: 12 min. cessation of nasal oxygen	119	7.11	89	
Second postoperative day	57	7.42	91	Sensorium clear
Eighth postoperative day	56	7.38	95	Lung expanded; sensorium clear

tration of a high concentration of oxygen to such a patient would remove the hypoxic stimulus to respiration, thus reducing ventilation; this reduction would be followed by more carbon dioxide retention, and eventually narcosis. In Case 2 unconsciousness finally occurred after such a sequence of events. This was quickly relieved when adequate ventilation followed the removal of the high oxygen concentration in the inspired air (Table 2). The practical procedure in such cases is to combat severe hypoxia with oxygen just concentrated enough to prevent serious hypoxic effects, yet adequate for automatic control of respirtion. As a further precaution, the administration of the increased oxygen should be intermittent.

Bronchospasm was an important factor in the development of respiratory acidosis in Case 1, and it was only after the relief of this that sufficient gas exchange occurred for control of the severe hypercapnia. This patient had never had asthma in the past, and the bronchospasm may have resulted from the hypercapnia. We have suspected this causal relationship in other patients, who, unfortunately, did not have adequate blood-gas studies. In the laboratory, Peters [5] was able to produce bronchospasm in dogs by acute hypercapnia. Irrespective of any cause-and-effect relationship, the hypercapnia cannot be corrected as long as significant degrees of bronchospasm exist. In our experience, bronchodilators and aminophylline are not reliable, and the only really effective method of control of this type of serious respiratory obstruction is the administration of hydrocortisone intravenously, followed by an adequate maintenance dosage until the patient is convalescent.

In patients with both acute and chronic respiratory acidosis, adequate aspiration of the tracheobronchial secretions is most important. In Case 1 it was necessary to do a tracheotomy, and now we should do this on emphysematous patients, similar to the one in Case 2, immediately after operation as a preventive measure. The usual methods of tracheal aspiration are not adequate for such poor-risk patients.

The recognition of respiratory acidosis is unusually difficult in the postoperative period. The narcotizing effects of carbon dioxide on the central nervous system may be masked by the postoperative sedation. In both our patients, an unstable blood pressure occurred, the pressure falling almost to shock levels. This was related to increases in the hypercapnia. This finding, along with bizarre neurological changes, is hard to evaluate and may be confused with shock or some other form of circulatory collapse. The clinical diagnosis has to be made by careful evaluation of the history, physical findings, operative procedure, and the appearance of such things as bronchospasm, mental confusion, unstable cardiovascular system. A low arterial pH and high carbon dioxide tension in arterial blood will confirm the presence of respiratory acidosis. If the latter determination cannot be done, then an elevated carbon-dioxide combining power with a low blood pH is evidence for respiratory acidosis.

The *sine qua non* of the treatment of respiratory acidosis is adequate ventilation. Mention has been made of hydrocortisone for relief of bronchospasm, tracheotomy for control of bronchial secretions, and careful utilization of oxygen in the chronic type of respiratory acidosis. If these measures are not effective, then it is necessary to use continuous artificial ventilation. In Case 1 the Drinker respirator was employed, even though large doses of sedation with meperidine (Demerol) were needed before the patient would tolerate it. In a more recent case, ventilation was obtained with a positive-negative respirator attached to an intratracheal tube inserted through a tracheotomy.

Prevention of respiratory acidosis is most important. Severely emphysematous patients and all asthmatics are given a cortisone compound before a thoracic operation, and this treatment is continued until they are ambulatory. In this same group, a

tracheotomy is done electively for reduction in the dead space and ready access to the respiratory tract. Clinical laboratory appraisal of the respiratory state has to be done before surgery in the poor-risk patient. When chronic respiratory acidosis is found, every measure is used to encourage ventilation. Particular attention is given to the proper use of oxygen therapy after operation.

Summary

Two cases in which patients developed post-thoracotomy respiratory acidosis are reported. The methods of treatment used for correction of this abnormal respiratory state are reviewed.

Duke University School of Medicine, Department of Surgery, Division of Thoracic Surgery (Dr. Sealy).

REFERENCES

1. Beecher, H. K., and Murphy, A. J.: Acidosis During Thoracic Surgery, J. Thoracic Surg. 19: 50-70, 1950.

2. Cohn, J. E.; Carroll, D. G., and Riley, R. L.: Respiratory Acidosis in Patients with Emphysema, Am. J. Med. 17:447-463, 1954.

3. Hickam, J. B.; Sieker, H. O.; Pryor, W. W., and Ryan, J. M.: Carbon Dioxide Retention During Oxygen Therapy, North Carolina M. J. 13: 35-37, 1952.

4. Motley, H. L.: The Use of Oxygen in Comatose States, Bull. New York Acad. Med. 26:479-494, 1950.

5. Peters, R. M.: Relationship Between Percent of Carbon Dioxide in Inspired Air and Degree of Bronchoconstriction, Ann. Surg. 142:461-466, 1955.

6. Taylor, F. H., and Roos, A.: Disturbances in Acid-Base Balance During Ether Anesthesia, with Special Reference to Changes During Thoracic Surgery, J. Thoracic Surg. 20:289-295, 1950.

Experiences with the Extirpated Canine Lung as a Biologic Oxygenator

GEORGE I. THOMAS, M.D.; JOHN E. JESSEPH, M.D.; NILES C. CHAPMAN, M.D., and K. ALVIN MERENDINO, M.D., Seattle

One of the more interesting oxygenators which has resulted from investigative search in the realm of pump oxygenators is the extirpated dog lung. These lungs, being inexpensive and readily available, have been extensively tested in the laboratory and provide an effective means of oxygenating blood.[2,4,5,7,10,11] In these experiments, the blood perfused through the "biologic" oxygenator has been homologous with it, and species difference was not considered. With homologous perfused lungs and, in some instances, perfused autogenous lobes, no deleterious effects on the organ were noticed, even after two hours of perfusion. The features of this extirpated organ adapting it to perform its exchange of oxygen and carbon dioxide have been summarized by Mustard, Chute, and Simmons, who state that it carries out good gaseous exchange without undue trauma to blood constituents, is an excellent filter for bacteria and small clots, and may perform certain detoxification functions.[8]

Early attempts to utilize canine and other mammalian lungs to serve as an oxygenating element for human blood met with failure. Massive edema and pulmonary congestion within minutes after beginning perfusion were the usual results when dog, pig, and sheep lungs were perfused with heparinized human blood.[13] Details of the technique were not included in this report, however. Mustard, Chute, and Simmons used the monkey lung as a biologic oxygenator in operating on infants with transposition of the great vessels.[9] All lungs functioned satisfactorily for periods of 10 minutes to 3 hours. The expense of these animals has restricted widespread experimental study, but has served as an impetus in the search for an inexpensive, yet efficient, heterologous lung substitute. After extensive laboratory work with the dog lung, Campbell et al. utilized the canine lung and a pumping system in attempts to correct a number of congenital and acquired cardiac defects.[3] Utilizing this system, they were able to support cardiopulmonary function from 15 to 49 minutes. They conclude that for short periods of time and relative low flow rates the biologic (dog) oxygenator is a reliable method for oxygenating blood. In order to define the limits of applicability of the dog lung, perfusion experiments employing human banked blood were carried out in this laboratory, using extirpated dog lungs. The prime objective was to obtain the largest rate of blood flow through the lung with the maintenance of its oxygenating capacity for a reasonable period of time.

Submitted for publication Jan. 17, 1957.

From the Department of Surgery, University of Washington School of Medicine.

Supported in part by U. S. Public Health Service Grant No. H-1110 (C4) and funds from the Washington State Heart Association.

U. S. Public Health Service Postdoctorate Research Fellow in Surgery (Drs. Thomas and Jesseph). Intern, King County Hospital (Dr. Chapman).

Method

A. *Preparation of Donor Lung.*—Mongrel dogs were anesthetized with intravenous pentobarbital sodium U. S. P. (25 mg. per kilogram) plus intravenous heparin sodium U. S. P. (2.0 mg. per kilogram). The left chest and abdomen were aseptically prepared by shaving and cleansing with 5% iodine and alcohol. Respirations were maintained with the mechanical Palmer respirator and

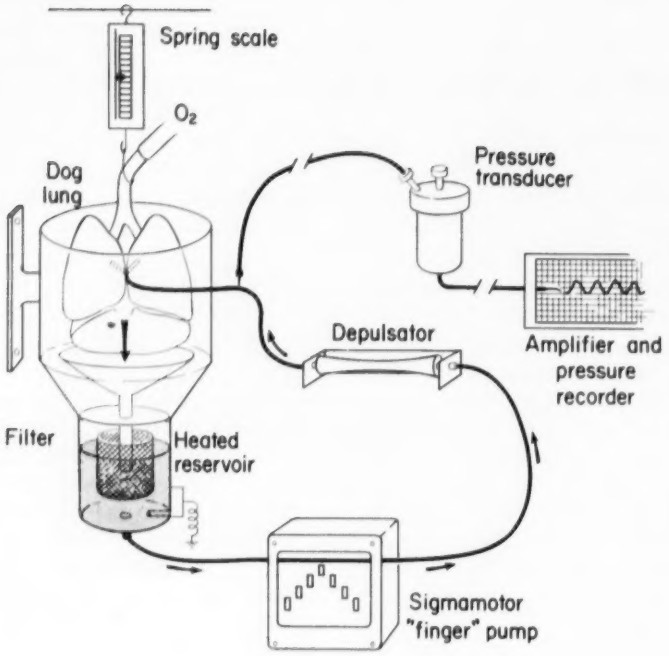


Fig. 1. — Experimental circuit used in perfusing extirpated dog lungs with human blood. The weight of the lung and pulmonary artery pressures were monitored at various flow rates, determined by the speed of the unidirectional "finger" pump (Sigmamotor).

endotracheal tube. After opening the chest, a large needle was inserted into the thoracic aorta, and through this needle lactated Ringer's injection U. S. P. was slowly pumped. Simultaneously, the left renal pedicle was transected. Exsanguination was accomplished within four to five minutes. Hemodiluting the circulating blood volume at this time aided in clearing the lung of its blood. The heart, lungs, and other mediastinal structures then were removed en bloc, with special attention to the avoidance of contamination on cross cutting the trachea and esophagus. A clamp was applied to the pulmonary artery to maintain a closed circuit, and specifically to exclude air bubbles.

Cannulation: After the pleura, pericardial fat, aorta, heart, and esophagus were removed from the lungs, each pulmonary artery was separately cannulated. Precautions were taken to prevent the introduction of air. A standard endotracheal tube was inserted into the trachea and secured with ligatures. The pulmonary veins were not cannulated, each group being permitted to drain freely. Final cleansing of the lung was accomplished by perfusing prewarmed (30-35 C) dextran * solution through the lung, one side at a time, during which period the lung was gently ventilated. Satisfactory cleansing was indicated when the lung became completely white and the pulmonary venous drainage crystal-clear. This required from 750 to 2500 cc. of dextran solution per lung.

B. *Perfusion.*—After these initial preparations, the lung, with attached endotracheal tube and arterial cannulae, was suspended in a semivertical position within a large sterile receptacle (Fig. 1). The centrally located pulmonary venous channels on the ventral aspect of the lung were positioned immediately over a large Lucite funnel directing blood flow through a 200-mesh wire filter into a constant-heat-controlled reservoir below. The circuit was completed from reservoir to lung by means of plastic tubing (Tygon) passed through the Sigmamotor pump and, in addition, through a short, 8 cm., segment of soft rubber tubing (Penrose), which behaved as a depulsator. Ventilatory exchange was accomplished by means of an automatic Palmer respirator, or, on occasion, hand ventilation was carried out with a Stevens-Slater valve and bag. Both methods were effective as long as the oxygen flow was maintained at 6 to 10 liters of oxygen per minute. A tidal volume of 300 to 450 cc. maintained the intratracheal pressure at 8 to 10 cm. of water and prevented overdistention of the lungs. Banked human blood was warmed to temperatures ranging from 35 to 37 C and filtered through standard transfusion filters prior to use.

* Plavolex, provided by Wyeth Laboratories, Inc., Philadelphia.

After completion of the closed, air-free circuit, a saline-filled No. 20 needle, attached to a pressure-recording system (Statham gauge to Sanborn amplifier), was inserted in the plastic tubing just proximal to the pulmonary artery cannulae, thus permitting continuous monitoring of the pulmonary arterial pressure during perfusion. The pump's flow having been calibrated, the rate was set at a lower level than desired. Within one to two minutes after the pump started, the flow rate was gradually increased to the desired level, permitting the lung to adjust to its hemodynamic load. The minimal perfusion period was arbitrarily set at 30 minutes.

Lung biopsy specimens before and after perfusions were obtained from both the upper and the lower lobes. Serial weight recordings were made by suspending the lung on a spring scale. Gas analyses and plasma hemoglobin levels were determined before and after the perfusions.

Results

The criterion of success was established as follows: A perfusion was considered satisfactory when minimal weight gain occurred (0 to 100% weight increase), pulmonary arterial pressures remained below 40 mm. Hg, and pulmonary and tracheobronchial edema was minimal or absent.

Forty-two perfusions were carried out in this study. The first 19 perfusions are excluded from this analysis, as these represented a trial period necessary in evolving a standard preparation. These preliminary perfusions established two important factors, viz., that osmotically active dextran was the agent of choice for cleansing the lungs of blood, thus preventing excessive fluid retention, and that warming of blood (35 to 37 C) was necessary (Fig. 2).

The remaining 23 perfusions were carried out as outlined previously. Figure 3 represents this group, divided into four categories. Sixteen perfusions were classified as satisfactory, with seven classified as unsatisfactory. Six of the latter were lungs perfused at flows greater than 60 cc. per kilogram (of the dog's original weight) per minute. The remaining lungs, perfused from 20 to 59 cc. per kilogram per minute, were entirely satisfactory, with one exception, and remained effective oxygenators for 30 minutes to 1 hour.

Relationship of Flow Rates to Gain in Lung Weight.—The satisfactory lungs perfused at 20 to 59 cc. per kilogram per minute showed a constant, gradual gain in weight during the perfusion period. This weight gain varied from 40% to 100%, with an average of 82%. An initial 10% to 25% weight increase reflected filling of the lung's vasculature with blood; the additional weight gain corresponded to the

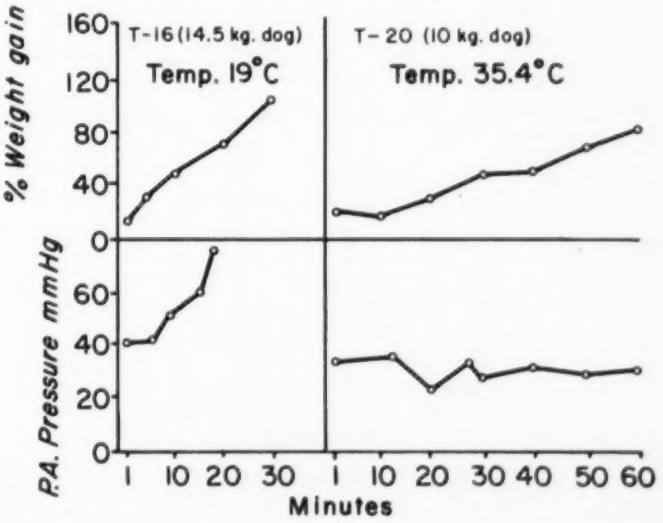


Fig. 2.—Effect of cold (19 C) and warm (35.4 C) blood on the lung in terms of pulmonary arterial pressure, lung weight, and duration of perfusion. A 60-minute perfusion with low pressure and negligible edema resulted with prewarmed blood.

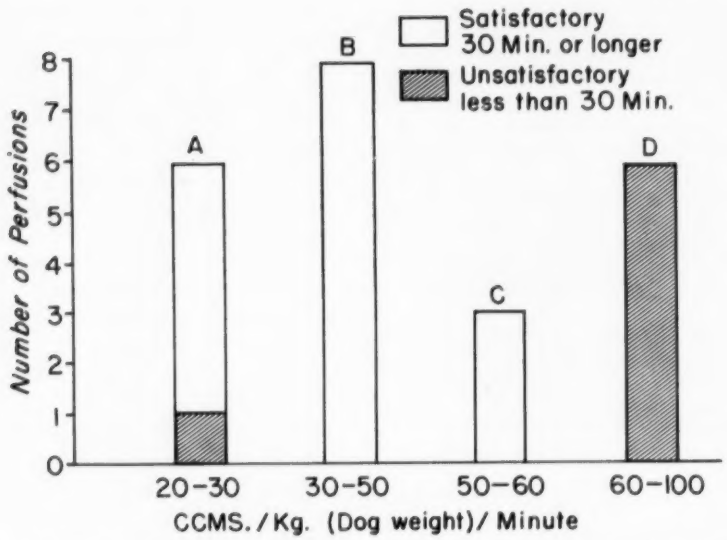


Fig. 3.—Results for 23 dog lungs—human blood perfusions broken down into four flow categories, showing the unsatisfactory results when the lung is perfused at flow rates greater than 60 cc. per kilogram per minute.

amount of blood lost from the reservoir and retained within the lung parenchyma. With flows above 60 cc. per kilogram per minute, large weight gains resulted, which limited the duration of perfusion. Figure 4 represents the weight gain of five of these lungs and the duration of each perfusion. The average was 18 minutes.

Relationship of Pulmonary Arterial Pressure to Gain in Lung Weight.—In lungs per-

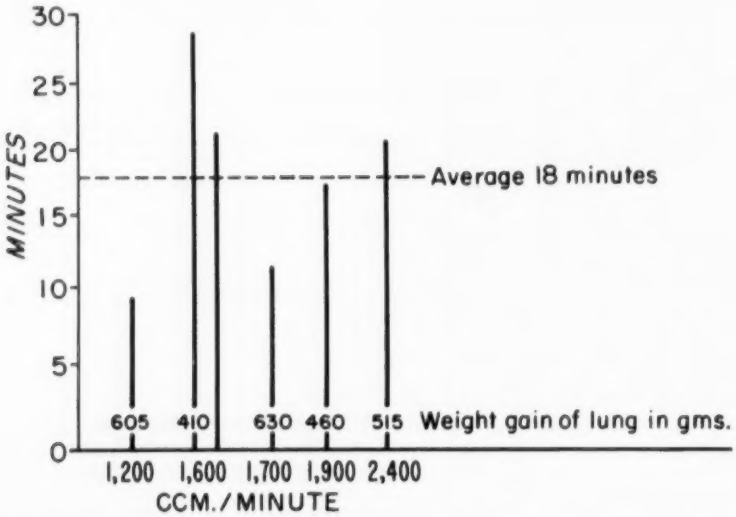


Fig. 4.—Six "high-flow" perfusions, with flow rates of 60 to 100 cc. per kilogram per minute, showing the short average duration of perfusion and an average weight gain of 350% over the original weight of the dog lung.

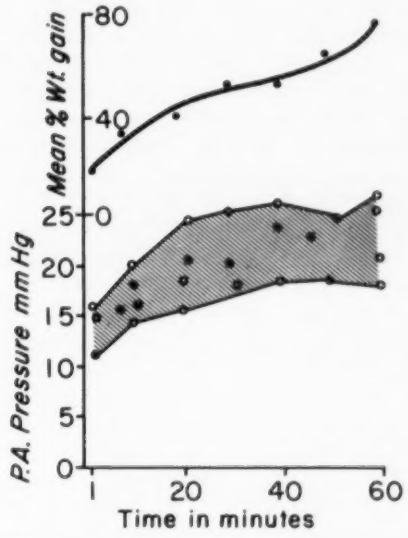


Fig. 5.—Pulmonary artery pressure curve of four perfusions of 30 cc. per kilogram per minute ("satisfactory") closely correlates in form with the mean per cent weight gain of the four lungs.

fused at a flow of 30 cc. per kilogram per minute, there was an important correlation of pulmonary artery pressure and percentage weight gain. Figure 5 shows the similarity in curvilinear relationship. Again, at low flows for 30 minutes the pressure of the pulmonary artery was below 40 mm. of Hg, frequently under 25 mm. of Hg as a mean pressure. In lungs perfused at flows above 60 cc. per kilogram per minute, pressures exceeded 40 mm. of Hg within minutes after starting perfusion, and often reaching levels of 100 to 140 mm. of Hg. The latter pressures were always associated with a large gain in lung weight.

Relationship of Flow Rates to Gas Analysis.—Important in the concept of lung life during these perfusions was the ability of these lungs to deliver oxygen to the blood and remove carbon dioxide, despite gradual or rapid gain in weight. Figure 6 represents initial and late "scattergrams" of the gas analyses determined during 10 experiments, with an average duration of 47 minutes. Specimens were obtained within 15 seconds of the start of the perfusion to avoid erroneous results from the repassage of reservoir blood through the lung. Late samples were obtained likewise using fresh quantities of venous blood. The first six perfusions (black dots) were lungs classified as satisfactory, having low flow rates of 30 to 50 cc. per kilogram per minute, for an average period of 73 minutes. The remaining four (circles) were lungs perfused at high flow rates (60 to 100 cc. per kilogram per minute), for an average of 21 minutes and classified as unsatisfactory. All lungs showed an excellent ability to exchange oxygen and carbon dioxide. This was most striking in those four lungs which by physical characteristics were considered unsatisfactory. The ability of the lung oxygenator to remove carbon dioxide is demonstrated by the low figures (below 30 vol. %), both in the initial and in the late periods of lung life. Oxygen levels varied from 15 to 22 vol. %, and were somewhat higher in the late stages of perfusion, averaging 7 vol. %, greater. In the satisfactory group of lungs, one expects gaseous exchange approaching these levels. By virtue of palpable and visible lung edema in the

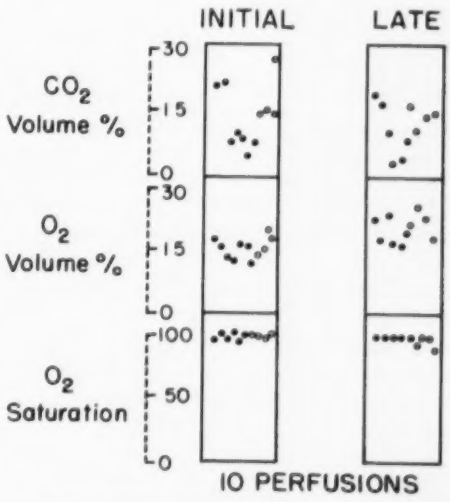


Fig. 6.—Scattergrams representing gas analyses, early and late, in 10 standard perfusions. Black dots represent satisfactory perfusions; circles represent unsatisfactory perfusions. Note similarity of results.

unsatisfactory group, the tremendous reserve of the organ is amply demonstrated during the failing period under high flow rates. This cannot be construed, however, as an ability to function indefinitely despite increasing edema, since a more advanced stage soon develops, with completely blocked arterial pathways, little or no pulmonary venous drainage, massive tracheobronchial froth, and completely consolidated lobes.

Miscellaneous Findings

Plasma hemoglobin levels were determined serially in 11 experiments. In seven experiments (62.6%) the average increase in plasma hemoglobin was 29.5%. In the other four, with higher perfusion flow rates, the plasma hemoglobin level increased 300% to 400%. The wide spread in the degree of hemolysis is in part related to the blood utilized, since most of the banked venous blood was over three weeks old, with an increased fragility of the red cells. It is obvious, however, that perfusions at higher flows for longer periods of time do increase hemolysis.

Gross observations on, as well as microscopic sections of, the lungs classified as satisfactory revealed a difference in reactions between the upper and the lower lobe. Usually the upper lobe of the lung retains the delicate, lace-like alveolar wall pattern, with only a trace of endothelial-wall edema. The lower lobe of the same lung reveals intact alveolar sacs and ducts but edematous alveolar walls and fluid-filled spaces. These changes in the dependent, or lower, lobes were constant despite the relative normal gross appearance of most of the satisfactory perfusions. Hemorrhagic infiltration and congestion, disruption of alveolar pattern, and fluid-packed air spaces are characteristic of consolidated lobes of the unsatisfactory group.

Comment

Utilizing the homologous lung preparation in an experimental perfusion circuit, certain well-established flow rates were obtained which did not alter the lung in any serious degree or remove from the circuit any appreciable amount of blood. These flow rates did not exceed 60 cc. per kilogram per minute for a variety of animal sizes. Restricted by the size of the species and their lung size, flow rates of only 1500 to 1800 cc. per minute were obtainable, utilizing dogs with weights of 25 to 30 kg. Clinically, this peak flow of 1800 cc. is too low for some adult patients.

This work failed to pinpoint the possible reasons for obtaining satisfactory results with low perfusion rates only. Perfusions through extirpated dog lungs with dog blood from either a reservoir system or a heart-by-passed animal reveal a larger capacity in terms of flow rates and duration. Flow rates of 60 to 75 cc. per kilogram per minute have been achieved with homologous blood for periods of one to two hours with no appreciable edema or congestion occurring. The inference therefore is that the pulmonary vasculature of the dog lung may react unfavorably to human blood in vitro as a biologic oxygenator.

Certainly, the red cells from both species are incompatible when mixed. Even in dilute solutions (1:10) agglutination and clumping occur. Though the lungs are washed of their dog cells, microscopic examination of the pulmonary venous return during dextran rinsing discloses some red blood cells still remaining. If capillary obstruction resulted from agglutination, edema and congestion would be expected to occur at even low flow rate. This does not occur, however, until the rate of perfusion reaches 60 cc. per kilogram per minute.

Mechanical trauma to the capillary bed is another possible explanation why high flows are unobtainable for longer periods. Certain studies reveal the lung to be an extremely sensitive organ with a delicate vasculature. Wearn et al., in studying capillary flow in the intact dog lung under quartz-rod-illuminated microscopy, observed marked fluctuations in the size of these vessels, as well as variations in flow rates and patterns.[12] In general, however, the most

characteristic type of flow was a rapid-moving, single layer of red cells coursing through a capillary. When constriction of the vessel occurred, as was frequent, the corpuscle appeared squeezed and its passage was delayed. MacGregor, in observing the pulmonary vascular response in isolated perfused cat lungs by microscopy, noted that in response to an increase in total pulmonary circulation and pressure there was a proportional increase in flow rates through each unit capillary, despite enlargement of the total capillary bed, from potential, but heretofore unused, quiescent capillary channels.[6] Since the diameter of the human red cell is 0.7μ to 1.0μ greater than that of the dog red cell, one might assume that each capillary unit is likewise smaller in the dog than in the human, though this is merely a guess.[1] Regardless of comparative sizes, the handling of the lung and exposure to room air produce capillary wall constriction within the lung.[12] In the attempt to force increased amounts of blood at higher ejectile pressures through constricted capillary vascular beds, divorced from vasomotor control, capillary wall damage undoubtedly occurs. The element of anoxemia and its role in capillary wall changes also may play an important role. Whatever the direct cause, obstruction to flow occurs, with resultant hemorrhagic congestion and edema. That this mechanism is irreversibly triggered at flow rates of 60 cc. per kilogram per minute, and not at lower flow rates, appears to be principally a function of load accommodation and the inability of the capillary bed of the dog's lung in vitro and under unphysiologic conditions to adjust to this increased blood volume.

Summary and Conclusion

Forty-two perfusions of human banked blood through extirpated dog lungs were carried out for experimental evaluation of this "biologic" oxygenator.

Dog lungs perfused for 30 minutes at flow rates of 20 to 59 cc. per kilogram (dog weight) per minute satisfied an arbitrary criterion for success. Higher flow rates were not tolerated by the heterologous lung under the conditions of our preparation and equipment.

Total flow rates of 1500 to 1800 cc. per minute of well-oxygenated blood were obtained for 30 minutes when 30 kg. dogs were used. These flows are adequate clinically for patients weighing up to 30-35 kg. approximately, but are inadequate for some adult patients.

Time-consuming preparation, possible contamination during staged procedures, limited duration, and relatively low blood flows are disadvantages inherent in the use of the "biologic" oxygenator and preclude widespread clinical application.

Department of Surgery, University of Washington School of Medicine (5).

REFERENCES

1. Albritton, E. C., Editor: Standard Values in Blood, prepared under the direction of the Committee on Handbook of Biological Data, American Institute of Biological Sciences, National Research Council, Philadelphia, W. B. Saunders Company, 1953, p. 45.

2. Campbell, G. S.; Crisp, N. W., and Brown, E.: Maintenance of Respiratory Function with Isolated Lung Lobes During Inflow Occlusion, Proc. Soc. Exper. Biol. & Med. 88:390, 1955.

3. Campbell, G. S.; Crisp, N. W., and Brown, E. B.: Total Cardiac By-Pass in Humans Utilizing a Pump and Heterologous Lung Oxygenator (Dog Lungs), Surgery 40:364, 1956.

4. Cohen, M., and Lillehei, L. W.: Autogenous Lung Oxygenator with Total Cardiac By-Pass for Intracardiac Surgery, S. Forum 4:34, 1953.

5. Cohen, M.; Warden, H. E., and Lillehei, C. W.: Physiologic and Metabolic Changes During Autogenous Lobe Oxygenation with Total Cardiac By-Pass Employing the Azygous Flow Principle, Surg. Gynec. & Obst. 98:523, 1954.

6. MacGregor, R. G.: Examination of the Pulmonary Circulation with the Microscope, J. Physiol. 80:65, 1933.

7. Mustard, W. T., and Chute, A. L.: Experimental Intracardiac Surgery with Extracorporeal Circulation, Surgery 30:684, 1951.

8. Mustard, W. T.; Chute, A. L., and Simmons, E. H.: Further Observations on Experimental Extracorporeal Circulation, Surgery 32:803, 1952.

9. Mustard, W. T.; Chute, A. L.; Keith, J. D.; Sirek, A.; Rowe, R. D., and Vlad, P.: A Surgical

Approach to Transposition of the Great Vessels with Extracorporeal Circuit, Surgery 36:39, 1954.

10. Potts, W.; Riker, W. L.; DeBord, R., and Andrews, S. C.: Maintenance of Life by Homologous and Mechanical Circulation, Surgery 31:161, 1952.

11. Read, R. C.; George V. P.; Cohen, M., and Lillehei, C. W.: Cardiac By-Pass Using Autogenous Lung for Oxygenation, Surgery 40:840, 1956.

12. Wearn, J. T.; Einsterne, A. C.; Brown, A. W.; Ban, J. S.; German, W. J., and Zschiesche, L. J.: The Normal Behavior of the Pulmonary Blood Vessels with Observations in the Intermittence of the Flow of Blood in the Arterioles and Capillaries, Am. J. Physiol. 109:236, 1934.

13. Wesolowski, S. A.; Fisher, J. H., and Welch, C. S.: Heart-Lung By-Pass Using Pumps and Isolated Homologous Lungs, Surg. Gynec. & Obst. 95:762, 1952.

Aortic Commissurotomy for Calcific Aortic Stenosis Under Direct Vision Using Hypothermia

BENJAMIN WINTER, M.D., F.R.C.S. (Edin.), F.R.C.S. (C), F.C.C.P., F.A.C.S.;
WILLARD J. ZINN, M.D., and BERTRAM J. ALLENSTEIN, M.D., F.C.C.P., Los Angeles

The surgery for aortic stenosis has been unsatisfactory. With the development of open heart techniques, it is now possible to attack aortic stenosis directly with reasonable hope for a satisfactory outcome. It is too early to know which method of open heart surgery will eventually emerge as the method of choice. In the following case, using hypothermia, operation was sucessfully performed under direct vision for rheumatic calcific aortic stenosis.

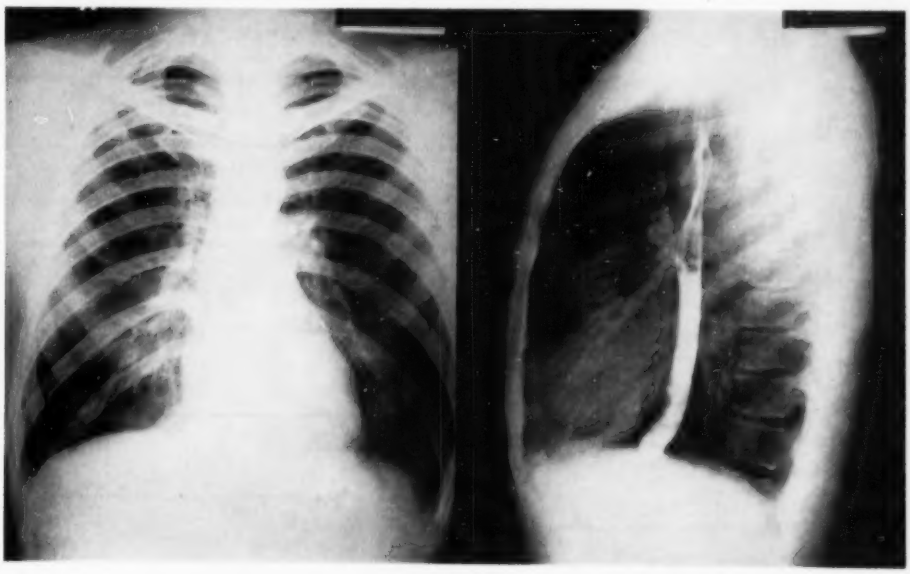
Report of a Case

A white man, age 38, stated he had had measles and mumps in childhood and a tonsillectomy at the age of 7; he denied having had rheumatic fever, joint pains, or chorea. He served as a flier in the Marine Corps from 1942 to 1946, without any disability. On his discharge from the Corps, the examining physician "thought" that he heard a murmur, but none was recorded on the records. This was the first time that anyone had called attention to his heart. In 1950 he was recalled to active duty with the Marine Corps, but was rejected because of an obvious heart murmur. In 1955 the murmur was reported as very loud, harsh, and rough. At this time his symptoms consisted of an increased pounding of the heart with exercise, profuse perspiration both at rest and with exercise, and a marked febrile response to mild infections.

Physical Examination.—The patient was 6 ft. 2 in. (188 cm.) in height and weighed 152 lb. (68.9 kg.), and was lean and muscular and in no distress. The color was somewhat pale. The neck veins were not distended or pulsating. The lungs

Submitted for publication Jan. 12, 1957.

Fig. 1.—Posteroanterior and left lateral roentgenograms of chest showing cardiac size to be within normal limits.



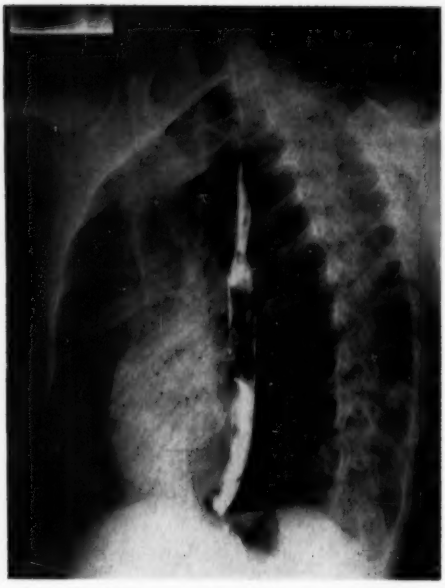


Fig. 2.—Right anterior oblique roentgenogram showing calcification of the aortic valve area.

were clear to percussion and auscultation. The pulse was regular, at 72 per minute. The pertinent physical findings were limited to the heart. The point of maximal impulse was in the fifth interspace, just to the left of the midclavicular line. A systolic thrill was felt over the base of the heart and the carotid arteries in the neck. The pulmonic second sound was heard but was faint. The aortic second sound was not heard. A Grade 4 systolic murmur was heard over the primary aortic area and was transmitted upward into the neck, into both carotid arteries. It was also heard in the right interscapular area. A high-pitched, diminuendo, minimal diastolic murmur was heard transmitted down the left border of the sternum in the third and fourth left interspaces. The liver was not enlarged. The spleen was not palpable. Abdominal aortic, and femoral popliteal, posterior tibial, and dorsalis pedis arterial pulsations were present at all points. There was no edema, and there were no varicose veins. There was no clubbing of the fingers or toes.

X-rays of the chest revealed no evidence of cardiac enlargement, but definite calcification of the aortic valve was seen (Figs. 1 and 2).

Fluoroscopy was performed. The lung fields were clear. The diaphragm moved normally. The pulmonary vascular markings were normal. The heart was normal in size, shape, and contour. The barium-filled esophagus descended in the normal manner. A very definite "pawnbroker's" sign was seen in the right oblique view, where one could detect the calcification of the aortic valves as they flipped back and forth.

Laboratory Investigations.—Serology, negative; RBC, 4,700,000; Hgb, 13 mg. per 100 cc.; WBC, 9700 per cubic millimeter, with 54% polymorphonuclear leukocytes, 46% segmented forms, 8% nonsegmented forms, 39% lymphocytes, and 7% monocytes. The urine was clear, with a pH of 7.5, a specific gravity of 1.024, negative reactions for

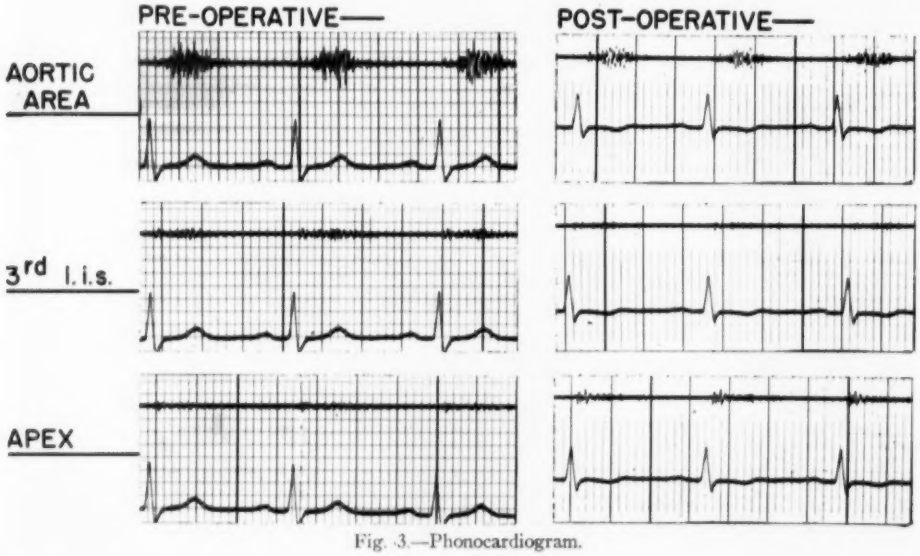


Fig. 3.—Phonocardiogram.

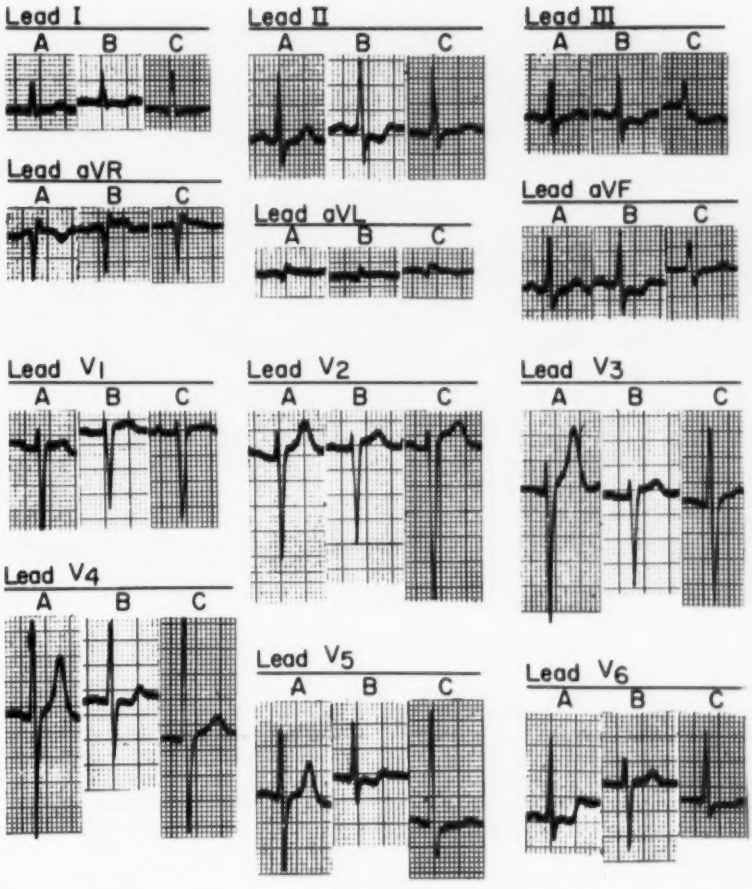


Fig. 4.—Electrocardiogram. *A*, 18 months preoperative; *B*, 1 day preoperative; *C*, 2 months postoperative.

protein and sugar, and 1 white blood cell per high-power field. The sedimentation rate was 4 mm. in one hour. Urea nitrogen was 16.8 mg., total protein 6.6 gm., albumin 5.6 gm., and globulin 1.0 gm., per 100 cc. The vital capacity was 5000 cc., which was 108% of normal for this patient.

Intracardial and Arterial Pressures and Oxygen Saturations

	Pressure, Mm. Hg	Oxygen Saturation, %
Superior vena cava	2/0	76.0
Right auricle	1/0	79.7
Right ventricle	20/ to 22/2 to 3	76.0
Main pulmonary artery	20/ to 22/5 to 6	76.5
Peripheral pulmonary artery	7/0	

The phonocardiogram corroborated the position and timing of the murmurs heard at auscultation (Fig. 3, *preoperative*).

The electrocardiogram showed right axis shift, a semivertical position, and lateral wall myocardial ischemia (Fig. 4A).

Cardiac catheterization was performed and revealed normal right heart intracardiac pressures and oxygenation, as shown in the Table.

The brachial artery pressure was 90/65 mm. Hg, with an oxygen saturation of 90%. The brachial artery pressure curve indicated a severe degree of aortic stenosis (Fig. 5).

The investigation revealed a calcific aortic stenosis with minimal aortic insufficiency of rheumatic origin, inactive. Surgery at this time was not recommended because of minimal symptoms.

Between April, 1955, and October, 1956, a considerable change in symptoms became evident,

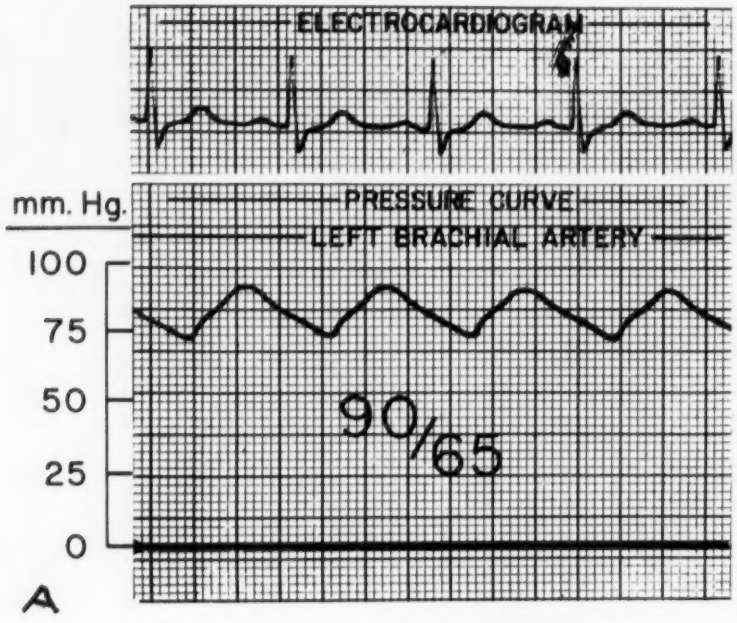


Fig. 5.—Brachial artery pressure curve, preoperative.

particularly in the six months prior to surgery. There was an increasing consciousness of the heart and apparent increased cardiac irritability. At night the heart would pound hard, miss beats, and at times suddenly slow down until it seemed to be stopping completely. This condition was relieved by sleeping propped up in bed or by sitting up in a chair. In the two months prior to surgery, the patient spent almost every night sitting in a chair. He noticed increasing tiredness and shortness of breath. Walking one and one-half blocks to his lathe at work made him breathless. He was forced to eat small meals at dinner because a large meal produced shortness of breath and palpitations. In the last two months he had noticed almost daily periods of lightheadedness, which subsided spontaneously with rest.

In October, 1956, the x-rays showed no change in the heart size. The electrocardiogram showed increasing lateral myocardial ischemia and was believed indicative of left ventricular hypertrophy (Fig. 4*B*).

At this point the patient was seen by several cardiologists in consultation. All consultants agreed that the patient's heart was beginning to show signs of difficulty in meeting the demands on it, namely, early left ventricular insufficiency and increased myocardial irritability. Surgical relief of the obstruction was recommended unanimously.

Description of Operation.—1. Premedication: 6:30 a. m. meperidine (Demerol) hydrochloride, 75 mg.; atropine sulfate, grain 1/200 (0.30 mg.).

2. Anesthesia: The patient was intubated under topical anesthesia while still awake. A rectal thermocouple was inserted.

	Started	Ended
1. Thiopental	7:00 a. m.	7:02 a. m.
2. Ether	7:05 a. m.	9:20 a. m.
3. Oxygen	7:00 a. m.	1:15 p. m.

Into ice, 8:00 a. m. Out of ice, 9:30 a. m., at temperature of 33 C.

Surgery began at 9:45 a. m. and ended at 1:15 p. m.

3. Hypothermia Effects: Behavior of the heart under hypothermia and during surgery is illustrated in Figure 6A to 6C. Before hypothermia the patient had a normal sinus rhythm. Electrical depolarization (QRS interval) and combined de- and repolarization (QT interval) were normal. As ether deepened the anesthesia, a nodal rhythm appeared, which reverted to sinus rhythm as the anesthetic state stabilized. A light blanket protected the patient from direct contact with the ice, which completely covered him to the neck as he lay in the ice-filled tub. Over an hour and one-half period, the temperature rose briefly at onset to 37.5 C and then fell with increasing rapidity to 33 C at the time of removal from the ice. The continuous ECG monitor during this period showed only the expected slowing of the heart rate and prolongation of repolarization (*out of ice*, Fig. 6A). The temperature continued to drop after

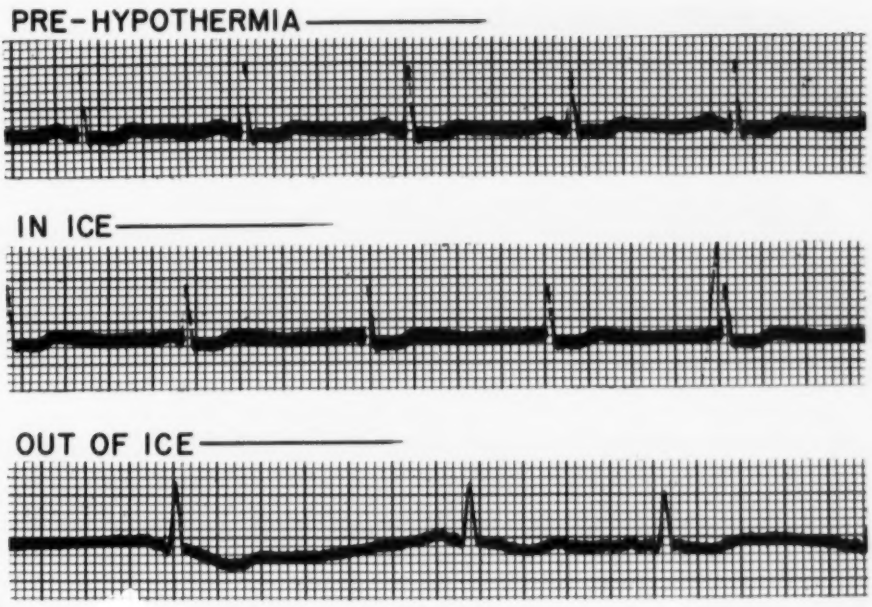


Fig. 6A. Electrocardiogram during hypothermia (Oct. 13, 1956); direct vision aortic commissurotomy.

removal from the ice, reaching a plateau about 5 degrees (C) below that noted on removal from the ice. At about 28 C, just prior to occluding inflow and outflow tracts of the heart, not only was repolarization prolonged and ST flattened, but depolarization had lengthened (*pre-occlusion*, Fig. 6B). The succeeding strips on Figure 6B show a phenomenon noted on several occasions when "isolated" hearts have had circulation restored after

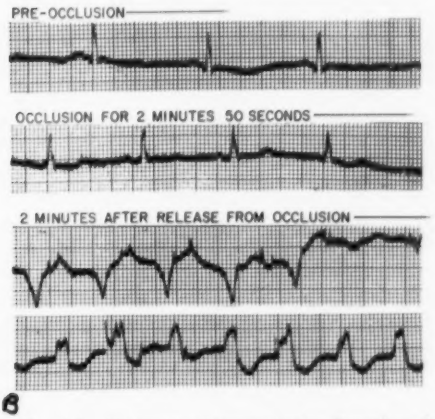


Fig. 6B.—Electrocardiogram during hypothermia (Oct. 13, 1956).

beating several minutes without a blood supply. The strip labeled *occlusion* shows a stable pattern, which persisted for the period of 2 minutes 50 seconds of actual occlusion. Within two minutes after circulation was restored to the heart, the onset of a ventricular tachycardia occurred, which, after a quarter-hour, spontaneously gave way to a higher pacemaker. On other occasions ventricular fibrillation has resulted during this period. Auricular fibrillation was later established (bottom of Fig. 6C) and reverted to normal sinus rhythm as the patient rewarmed. No artificial stimulus to rewarming was used, and physiologic restoration of normal body temperature was achieved in nine hours without incident.

4. Procedure: An incision was made anteriorly from under the right nipple across the sternum, and under the left nipple. The muscles were divided. The third interspace on the right side was opened up, and the fourth interspace on the left side. The internal mammary vessels were divided on both sides. The sternum was split, using a sternum knife. The lungs were retracted. The pleural attachments to the under aspect of the sternum were cut and the wound widely retracted. There was a very marked thrill over the ascending aorta. The ascending aorta was dilated. The pericardium was now widely opened. The heart appeared to be enlarged. There were no thrills over the right ventricle, the pulmonary artery, or the

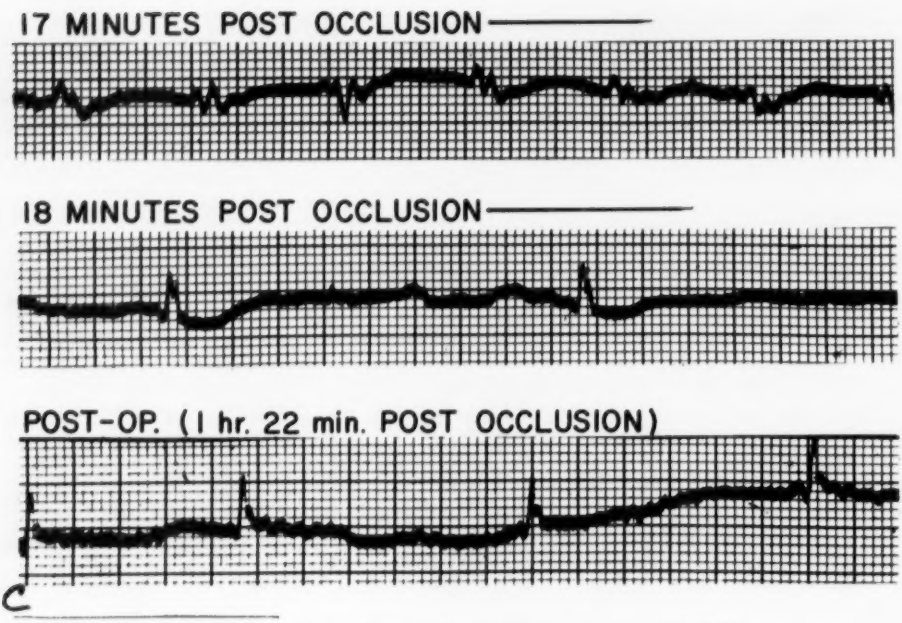


Fig. 6C.—Electrocardiogram during hypothermia (Oct. 13, 1956).

left ventricle. The patient appeared to have an isolated aortic stenosis with poststenotic dilatation of the ascending aorta. There was no evidence of calcification in the aortic wall. The coronary vessels appeared to be normal. The superior vena cava was dissected free below the entrance of the azygos vein and controlled by a tape. The inferior vena cava was dissected free and controlled by a tape. The pulmonary artery was dissected free and controlled by a tape. The aorta was mobilized up to the innominate artery. The adventitia was stripped from the anterior surface of the ascending aorta. An aortic clamp was placed to partially occlude approximately 1½ in. of the ascending aorta. The knuckle of aorta contained in the clamp was opened longitudinally. Four retraction sutures were placed in the open aorta. At this point the lungs were inflated for several minutes. In rapid succession, the superior vena cava was clamped, the inferior vena cava was clamped, the pulmonary artery was clamped, and the aorta was clamped. The partial occlusion clamp was removed. The aorta was opened widely, and the blood was sucked out. The aortic valve was seen and palpated. It was heavily calcified. Two of the commissures were open, but, due to the calcium, the opening was small and rigid. The third commissure was identified only when the finger was inserted through the orifice and the valve elevated, at which time it was demonstrated and cut. The valve now opened up readily in its tricuspid state, and mobility was restored. The pulmonary artery clamp was then removed and the air flushed out of the heart with blood. The partial occlusion clamp was applied across the opening in the aorta. The clamps were quickly removed from the superior vena cava, inferior vena cava, and aorta. There was ventricular tachycardia but no fibrillation. The incision in the aorta was closed with a double layer of continuous fine 0000 arterial silk. The clamp was then removed. The thrill in the aorta was dramatically reduced, although it could still be palpated. There was no thrill over the left ventricle following surgery. In a few minutes the heart suddenly settled down to a slow ventricular rhythm. Both sides of the chest were drained. The sternum was approximated with wire, and the incision was closed. The patient left the operating room in excellent condition. The time of total occlusion of blood flow to the heart was 2 minutes 50 seconds.

Postoperative Course.—The patient was not rewarmed by any artificial means. The body temperature was allowed to return spontaneously to its normal level. Voluntary respiration returned easily. Movement of all four limbs was noticed early in the rewarming period. The patient was fully conscious and normothermic nine hours from the onset of the hypothermia. The chest catheters were removed 24 hours following surgery. The

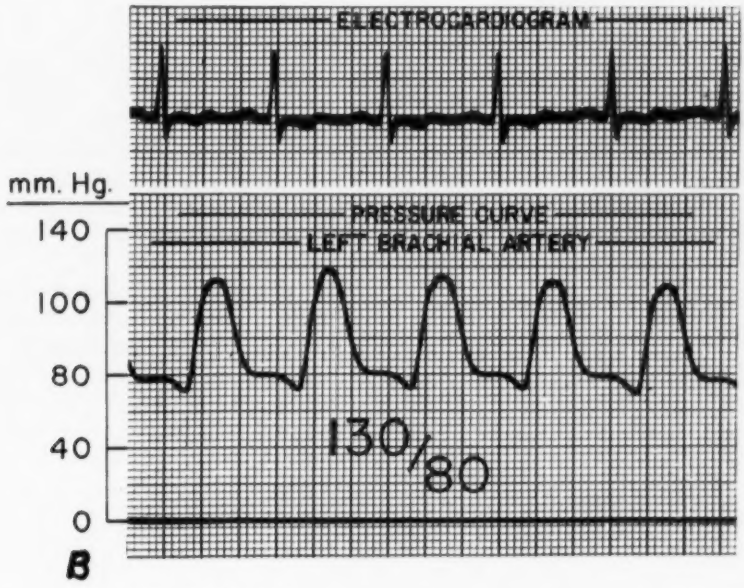


Fig. 7.—Brachial artery pressure curve, postoperative.

patient was out of bed on the second postoperative day and returned home 10 days after surgery.

Two months postoperatively repeat brachial artery pressure measurements and curves were made, using the same apparatus as was used preoperatively. The postoperative brachial artery pressure was seen to be 130/80 mm. Hg (Fig. 7). The contour of the brachial artery pressure curve showed a return to a normal physiologic tracing. The phonocardiogram revealed a dramatic change in the murmurs, with no evidence of aortic insufficiency (Fig. 3, *post-operative*). The electrocardiogram (Fig. 4*C*) revealed a return of the T-waves toward normal. The patient has remained well, has no symptoms referable to his heart, and has returned to work.

Comment

The restoration of function in the presence of extreme calcification of the aortic valve is one of the remarkable features of this case. At first inspection there seemed to be little hope of improving this patient's condition. Two of the commissures were held rigidly open, and the orifice of the valve was narrow. All three cusps were an apparent solid mass of calcium. The three commissures could not be identified. It was only when the finger was inserted through the valve into the ventricle and the valve elevated on the tip of this finger that the line of fusion of the commissures became evident. The apparently solid mass of calcium tented up along the commissural line, revealing the line for incision between the two valve cusps. When this was cut, the valve spread open and, although each cusp was rigid in itself, satisfactory motion was obtained. The stenosis was relieved, and the valve was able to function as a dynamic tricuspid mechanism, without any apparent aortic regurgitation.

Another prominent feature was that air did not flow into the openings of the coronary arteries even though the mouths of these vessels were exposed freely to the air in the presence of a contracting heart. Air embolism of the coronary artery appears to develop only when air is present in the aorta under the pulsatile pressure of the closed aorta. By allowing the heart and aorta to fill with blood from the lungs before the partial occlusion clamp was closed on the aorta and just before the distal aortic clamp was removed, coronary artery em-

bolism with air was avoided. Clamping of the right coronary artery was not necessary in this patient.

Very little time is required to perform an aortic commissurotomy. This case required 2 minutes 50 seconds of total occlusion of blood flow to and from the heart. The heart behaved well and did not develop the expected ventricular fibrillation. However, even with this short period of occlusion, ventricular tachycardia did develop after restoration of circulation. In more severely damaged hearts it seems likely that some form of artificially induced chemical cardioplegia will be advantageous in diminishing the accumulation of products of metabolism in the beating heart, and should further reduce the danger of cardiac arrhythmia when circulation is restored.

Summary

The case is presented of a 40-year-old white man who had calcific aortic valvular disease with stenosis. He had had progressive symptomatology for six months prior to surgery.

The patient has had an excellent response to surgical correction under direct vision, using hypothermia and without the use of any auxiliary pump apparatus. The procedure is described.

6423 Wilshire Blvd.

Herniated Lumbar Intervertebral Disks

Results of Surgical Treatment Without the Routine Use of Spinal Fusion

H. G. DECKER, M.D., and S. W. SHAPIRO, M.D., Des Moines, Iowa

Introduction

Since the original report, in 1934, of Mixter and Barr,[23] innumerable reports on the subject of herniated intervertebral disks have been recorded. At first glance, this condition would seem to offer few problems in diagnosis and management. Yet every series of cases contains a group of negative explorations and a group of poor results. It is apparent that differences of opinion regarding various phases of the management of patients suspected of having a herniated disk do exist. The purpose of this paper is to review some of these differences and to report our own experience with 347 explorations for lumbar disk herniation.

Review of Literature

In the presence of typical signs and symptoms, the diagnosis of a herniated lumbar intervertebral disk is not difficult. However, the accurate preoperative localization of the level of herniation has offered some problems, so that the methods used in localization have been a topic of considerable discussion. It is known that over 90% of lumbar disk herniations occur at the L4-L5 and L5-S1 levels and that, of these, the majority occur at the L5-S1 level.[24] This in itself has led some to believe that accurate preoperative localization is not important. Because of this, they explore the L5-S1 interspace first, and in over 50% of the cases the disk herniation is found; if this exploration is negative, the L4-L5 interspace is explored next. Others are of the opinion that in the majority of instances accurate localization can be accomplished on the basis of physical findings alone. Raaf and Berglund[27] found physical signs accurate in localization in 81.5% of their cases, while Woolsey and Tsang[34] found this method accurate in only 69% of their cases. Various physical signs and patterns of sensory disturbance have been listed as aiding in localization.[18] For example, Kugelberg and Petersen,[19] in a study of 66 patients, found that 90% of disk herniations at the L4-L5 level exhibited evidence of weak dorsiflexion, while only 16% of patients with herniation at the lumbosacral joint showed this abnormality. On the other hand, Davis et al.,[9] in a study of 500 cases of surgically proved lumbar disk herniations, found no correlation between the pattern of sensory disturbance and the level of herniation. They stated that myelography represented the most accurate method of localizing the level of disk herniation.

Myelographic accuracy has varied between 75% and 90% in different hands and with the contrast medium utilized.[1,14,20,21,34] In one study in which media were compared as to accuracy, iodized oil U. S. P. (Lipiodol) was found to be 88.9% accurate, whereas iophendylate (Pantopaque) was 76.7% accurate.[27] Those who rarely utilize myelography state that it is an unnecessary procedure, since in the vast majority of instances the disk herniation will be found at the L4-L5 or L5-S1 level. Advocates of the frequent or routine use of myelography as an aid in localization claim that the procedure is less harmful than the exploration of one or two extra interspaces.[27,34] Mention has been made of the

Submitted for publication Jan. 8, 1957.

From the Department of Surgery, Veterans Administration Hospital.

Attending Neurosurgeon (Dr. Decker); Senior Resident, General Surgery (Dr. Shapiro), Veterans Administration Hospital.

value of myelography in demonstrating multiple herniations occuring simultaneously. Non-disk lesions masquerading as herniated disks have been demonstrated by the myelogram. A number of surgeons reserve myelography for those cases which are not clear-cut clinically and in instances of postoperative recurrence of symptoms.[32]

Narrowing of an interspace, as shown by plain radiographs of the lumbosacral spine, has been observed to occur with relative frequency in association with lumbar disk herniations. Leader and Rassel[20] found narrowing of the lumbosacral joint in 70% of all disk herniations and narrowing of the L4-L5 interspace in one-third of the disk herniations at this level. The importance of finding a narrowed interspace as an aid in localization of the level of disk herniation has not been stressed.

Although there is agreement that symptomatic lumbar disk herniation requires surgical removal of the disk, the place of spinal fusion in the surgical treatment of this disease has not met with uniform opinion. Compere[8] has stated unequivocally that disk removal should always be accompanied by some type of spinal fusion. Cloward,[5-7] dissatisfied with the usual type of spinal fusion, has developed a technique of interbody fusion and claimed superior results. Grantham and Spurling[15] did not perform spinal fusion at the time of disk removal in a very large series of cases. Viewpoints midway between these two extremes have been expressed by several authors. Raaf and Berglund[27] did spinal fusions in 37.9% of their 224 cases, and as indications for fusion they listed spondylolisthesis, unstable joint, congenital anomalies, negative explorations, and patients with a good deal of back pain. Scuderi[30] listed spondylolisthesis, spina bifida, and osteoarthritic lipping as his indications for spinal fusion. Shinners and Hamby[31] did fusions in 18.5% of 359 cases. Opponents to routine or frequent spinal fusion at the time of disk removal have objected on the grounds that the results are not better, the morbidity of operation is increased, and, should reoperation be required, it becomes much more difficult.

The surgical management of the patient whose exploration is negative is another issue in which agreement is lacking. As indicated above, some would perform spinal fusion. Others would terminate the operation. Echols and Rehfeldt,[12] in a review of 32 cases of negative exploration, stated that rhizotomy should be seriously considered in such cases and were opposed to spinal fusion in instances of negative exploration.

Although the results of surgical management of herniated lumbar intervertebral disks have generally been good, several factors have complicated the interpretation of these results.[27,31,32] Many patients are "compensation cases." Differences in end-results are apparent when private cases are compared with charity cases. Associated diseases, such as arthritis and psychoneurosis, tend also to cloud the true picture. Patients with persistent symptoms following surgery are difficult to evaluate, and there is a 25% chance or greater that re-exploration will be negative in these patients.

Material and Methods

Between September, 1948, and January, 1955, a total of 347 patients suspected of having nerve root compression in the lumbar areas were subjected to surgery at the VA Hospital, Des Moines. All of the patients were seen by both the neurosurgeon and the orthopedic surgeon, and all had a trial of conservative therapy. All were operated upon by, or under the supervision of, one of us (H. G. D.).

The clinical and operative records were carefully reviewed in each case. Plain radiographs and iophendylate myelograms were available in every case for review, since it is our practice to obtain these studies routinely. These films were reviewed without benefit of history, operative findings, or knowledge of the original radiologic report. A questionnaire was sent to each patient, in which he was asked to indicate whether he felt "cured," "better," "the same," or "worse." He was asked to classify his preoperative symptoms of back pain, leg pain, and numbness in the same way, whether he was working full time or part time or was unable to work, and whether or not he required a back or foot brace. The data were transferred to I. B. M. punch cards, and from

these the information presented in the Tables was obtained.

Results

All but 2 of the 347 patients were men, ranging in age from 21 to 70 years. Patients in the third and fourth decades of life accounted for 64% of the series. Definite service connection was established in 31 cases. There were no deaths.

Herniated lumbar intervertebral disks were found in 279 cases, tumors in 3, and other pathology causing nerve root compression in 13. In the remaining 52 patients, exploration failed to reveal the cause of their clinical picture.

Of cases found to have a herniated lumbar intervertebral disk, the lesion was found at the lumbosacral junction in 166 (59.4%), at the L4-L5 interspace in 103 (37%), at the L3-L4 interspace in 8 (2.9%), and at the L2-L3 interspace in 2 (0.7%). Eight of the herniated disks were calcified; of these, two were at the L4-L5 interspace, and the remaining six, at the lumbosacral junction. In 172 cases the herniation caused bulging of the posterior longitudinal ligament, while in 99 cases the ligament had ruptured so that a free fragment of disk material was extruded into the vertebral canal. Multiple disk herniations occurring simultaneously were found in six cases.

The three tumors in this series included an ependymoma, a neurilemmoma, and an epidermoid cyst of the conus medullaris.

In 13 cases the nerve root compression was caused by conditions other than disk herniation or tumor. These included bony exostoses (six), arachnoiditis (four), congenital anomalies (two), and dilated epidural veins (one).

A comparison of the historical data and symptomatology of the three major groups of patients comprising this series is found in Table 1. No outstanding variation in symptomatology is apparent. Pain was the predominant symptom in all groups. The majority of patients complained of back pain and sciatic pain.

All of the patients who had negative explorations, or in whom other than disk pathology was found, complained of back pain preoperatively, whereas 5% of the herniated disk patients had no back pain. In the herniated disk series, 2% of patients had back pain without accompanying sciatic pain, whereas in the negative exploration series there was only one such instance. Aggravation of pain on coughing, sneezing, or straining occurred frequently in all groups. Subjective numbness in one or both extremities was present in about half of all cases. Most of the patients in all three groups attributed their difficulty to minor trauma, such as bending over to pick up an object, getting out of a vehicle, a twisting movement of the back, etc.

TABLE 1.—*Historical Data*

	Herniated Disks (279 Cases)	Negative Exploration (52 Cases)	Other Pathology (13 Cases)
Back pain	265 (95%)	52 (100%)	13 (100%)
Gluteal pain	133 (48%)	19 (37%)	3 (23%)
Sciatic pain	273 (98%)	51 (98%)	13 (100%)
Pain aggravation on straining	236 (85%)	39 (75%)	9 (69%)
Subjective numbness	128 (46%)	27 (52%)	6 (46%)
Major trauma	41 (15%)	9 (11%)	3 (23%)
Previous disk operation	16	8	2
(a) Done here	13	3	1
(b) Done elsewhere	3	5	1
(c) Same side & level	11	4	2
(d) Different side and/or level	5	4	0
Previous spinal fusion	4 (1%)	4 (8%)	3 (23%)

A definite history of major trauma, such as a fall or a blow to the back, was infrequently obtained. Twenty-six patients had had a previous disk operation; eleven had had a previous spinal fusion. If one considers only those patients who had had a previous disk operation, 30% had a negative exploration at the second procedure, as compared with an over-all incidence of 15% negative explorations for the entire series. In patients who had had a previous spinal fusion there was a 36% incidence of negative exploration.

The physical findings of the three major groups of patients comprising this series are compared in Table 2. Those signs dependent upon stretching the sciatic nerve were most commonly found in all groups.

TABLE 2.—*Physical Findings*

	Herniated Disks									
	L2-L3 (2 Cases)	L3-L4 (8 Cases)	L4-L5 (103 Cases)	L5-S1 (166 Cases)	Total All Disk Cases (279)		No Pathology Found (52 Cases)		Other Pathology (13 Cases)	
Lesague's sign	0	6 (75%)	93 (90%)	155 (94%)	254 (91%)		43 (83%)		10 (77%)	
Limited forward bending	1	6 (75%)	85 (83%)	146 (89%)	238 (88%)		36 (69%)		9 (69%)	
Localized tenderness	2	1 (12%)	74 (72%)	140 (84%)	217 (78%)		32 (61%)		10 (77%)	
Loss lumbar curve	2	3 (37%)	41 (40%)	65 (39%)	111 (40%)		19 (37%)		5 (38%)	
List	2	3 (37%)	55 (53%)	70 (42%)	129 (46%)		19 (37%)		2 (15%)	
Paravertebral muscle spasm	0	5 (62%)	59 (57%)	95 (57%)	159 (56%)		22 (42%)		4 (30%)	
Bragard's sign	1	1 (12%)	38 (37%)	67 (40%)	107 (38%)		15 (29%)		2 (15%)	
Sensory changes	1	3 (37%)	44 (43%)	77 (46%)	125 (45%)		26 (50%)		5 (38%)	
Weak dorsiflexion	2	4 (50%)	63 (61%)	104 (63%)	173 (62%)		21 (40%)		10 (77%)	
Depressed or absent Achilles reflex	2	3 (37%)	43 (42%)	136 (82%)	184 (66%)		22 (42%)		11 (85%)	

Significant variations between the groups were lacking. The group of 279 disk herniations was broken down into sites or levels of herniation in order to ascertain whether the physical signs varied with different levels. The results of this comparison are also seen in Table 2. Absence or depression of the Achilles reflex was observed with twice the frequency when the disk was herniated at the lumbosacral junction as it was when the disk protruded at the L4-L5 level. This was the only significant variation in the physical signs.

In order to determine the value of the plain x-ray, the anteroposterior, lateral, and oblique views of the lumbosacral spine, which were taken routinely in all cases, were reviewed. One or more narrowed interspaces were found in 162 cases, arthritic changes in 28 cases, and congenital anomalies in 22 cases. These data are broken down into the three major groups of patients in the series, and the herniated disk group is further broken down into levels of herniation in Table 3. As can be seen, narrowing of the interspace at the lumbosacral junction occurred with considerable frequency in all groups. In the negative exploration group, it was found in 20 (38%) instances, and in the L4-L5 group, in 24%. It occurred in 53% of the L5-S1 disk herniations. Narrowing of the L4-L5 interspace occurred in 17 of the 103 disk herniations at the same level and was not observed when the disk herniation was at any other level. It was observed in only two cases in the negative exploration group.

Iophendylate myelograms were obtained in all 347 patients. In 16 cases the myelogram was considered "unsatisfactory" for interpretation. This was usually due to fragmentation of the dye column or extradural injection of the dye. These 16 cases were therefore deleted from the total number of cases in computing the myelographic error, leaving a total of 331 determinate cases. In the 3 instances of tumor and in the 13 cases of non-disk pathology, the myelogram was accurate in localizing the level of the lesion. In 218 cases of disk herniation, the myelogram was also accurate in localizing the site of the lesion. In 14 instances of negative exploration, the myelogram was negative. In 13 cases the myelogram showed a defect and at surgery the disk was found one interspace above, or

TABLE 3.—*Plain X-Ray Findings*

	Herniated Disks (279 Cases *)			No Pathology Found (52 Cases)	Other Pathology (13 Cases)
	L3-L4 (8 Cases)	L4-L5 (103 Cases)	L5-S1 (166 Cases)		
Narrowed interspace					
L2-L3	0	0	0	0	0
L3-L4	0	0	0	0	0
L4-L5	0	17	0	2	0
L5-S1	4 (50%)	25 (24%)	89 (54%)	20 (38%)	5 (38%)
Arthritis	2	11	7	7	1
Congenital anomaly	1	4	11	4	2

* In 2 cases of L2-L3 herniation there were no x-ray changes.

one interspace below, the level reported by x-ray. These cases were again reviewed, and all discrepancies could be explained by errors in interspace identification, either on the x-ray or in the operating room. Lumbarization of the first sacral segment and sacralization of the last lumbar segment predisposed to this error of identification. There remained 35 cases in which the myelogram was reported negative and a herniated disk was found at surgery (false-negative) and another 35 cases in which the myelogram showed a defect but at surgery no pathology was discovered (false-positive). Thus, the error was 70 instances in 331 cases or a myelographic accuracy of 79%. Complications attributable to myelography were not encountered.

Replies to the questionnaire were received from 277 (80%) of the patients. The results are indicated in Table 4. As might be expected, the results in the nondisk pathology group, which included patients with arachnoiditis and bony exostoses, were not as good as in the other two groups. In the group of patients with herniated disks that were followed, 25% said they were cured and 67% said they were better, giving a total of 92% that were improved. There were 88% of the patients in the negative exploration group who said they were improved. Only 14% of these felt cured, however. Similar figures were obtained with reference to the status of sciatic pain, back pain, and ability to work. Relatively few were wearing a back brace, and in two of the herniated disk cases and in one case of arachnoiditis the patient was wearing a foot brace. Both these cases of foot drop occurred with herniated disks at the L4-L5 level.

Because we felt that there would be a definite difference in the results of cases in which there was a free disk fragment when compared with those in which there was only bulging of the posterior longitudinal ligament, the information from the questionnaires was further broken down into level of disk herniation and free fragment or bulge. No significant variation in over-all results was found when the levels of herniation were compared. A comparison of over-all results in disk herniations causing bulging of the posterior longitudinal ligament and those in which the ligament was torn so that a free fragment of disk material was extruded into the vertebral canal also showed no variation. These figures are included in Table 4.

Comment

If localization of the level of disk herniation is to be accurately made on the basis of physical findings alone, it must necessarily be based on alterations of the sensory, motor, and reflex functions. In many of the patients in this series a clear-cut pattern of sensory disturbance could not be demonstrated. Our impression is in agreement with Davis et al.,[9] who could find no correlation between the sensory disturbance

TABLE 4.—*Follow-Up Results*

	Herniated Disks (230 Cases Followed)									Negative Explorations (35 Cases Followed)			Other Pathology (9 Cases Followed)
	Bulge (147 Cases)		Free Fragment (83 Cases)		Total								
Feels cured	39	(26%)	19	(23%)	58	211	(92%)			5	31	(89%)	0	
Feels better	94	(64%)	59	(71%)	153					26			5	(56%)
Feels same or worse	14	(10%)	5	(6%)	19		(8%)			4		(11%)	4	(44%)
Sciatica cured	57	(39%)	32	(39%)	89	216	(94%)			9	31	(89%)	0	
Sciatica better	81	(55%)	46	(55%)	127					22			4	(44%)
Sciatica same or worse	9	(6%)	5	(6%)	14		(6%)			4		(11%)	5	(56%)
Back pain gone	36	(24%)	13	(16%)	49	190	(87%)			5	31	(89%)	0	
Back pain better	91	(62%)	59	(71%)	150					26			4	(44%)
Back pain same	16	(11%)	8	(9%)	24	31	(13%)			1	4	(11%)	4	(44%)
Back pain worse	4	(3%)	3	(4%)	7					3			1	(11%)
Works full time	101	(69%)	54	(65%)	155		(67%)			19		(54%)	1	(11%)
Works part time	37	(25%)	24	(29%)	61		(27%)			14		(40%)	4	(44%)
Can't work	9	(6%)	5	(6%)	14		(6%)			2		(6%)	4	(44%)
Wears back brace	20	(14%)	9	(11%)	29		(12%)			8		(23%)	4	(44%)
Wears foot brace	2	(1.4%)	0		2		(0.8%)			0			1	(11%)

and the level of disk herniation in a series of 500 cases. Weakness of dorsiflexion of the great toe or foot has been reported to occur with much greater frequency in herniations at the L4-L5 level, but in this series of cases weakness of dorsiflexion occurred with equal frequency at all levels of herniation. The only physical finding which was found to occur with varying frequency at different levels of herniation was impairment of the ankle jerk.

It would appear from this study that localization of the level of herniation based on physical findings alone was inaccurate. Since the ankle jerk was the only physical finding which varied with different levels of herniation, it would necessarily be the deciding factor if localization were to be accomplished by physical signs alone. If this is calculated, i. e., the accuracy of localization if cases exhibiting an impaired ankle jerk had been called examples of an L5-S1 herniation, the impaired ankle jerk would have been an accurate localizing index in 69% of the cases. This is little better than the 59.4% accuracy one would have had in this series by merely exploring L5-S1, since herniations at this level accounted for 59.4% of the cases.

Certainly, all would agree that x-ray examination of the lumbosacral spine is an important part of the evaluation of every patient suspected of having a lumbar disk herniation. Congenital anomalies, spondylolisthesis, and arthritic changes will be readily demonstrated by appropriate x-ray examination. Narrowing of one or more intervertebral spaces will also be demonstrated.

Most authors have reported that narrowing of the L5-S1 interspace occurs frequently in association with disk herniations at all levels and that it cannot be relied upon to localize the level of herniation. In this series the presence of L5-S1 narrowing in one-half of the L3-L4 herniations and in one-fourth of the L4-L5 herniations supports this view. The importance of narrowed interspaces at other levels has not been stressed, although Leader and Rassel [20] did mention that one-third of the L4-L5 herniations exhibited a narrowed interspace at the same level. In this series narrowing of the L4-L5 interspace was observed in 19 cases, 17 of which were subsequently shown to have disk herniation at the same level. The remaining two had negative explorations. Narrowing of the L4-L5 interspace did not occur in association with disk herniation at any other level. It would seem therefore to be of considerable value as a localizing sign when it is present.

Iophendylate myelograms were obtained in every patient in this series. The procedure was undertaken as an aid in localizing the level of the lesion and not as a diagnostic measure of the presence of disk herniation. It was an accurate aid in localization in 79% of the cases. Emphasis should be placed on the fact that these films were reviewed without knowledge of the fluoroscopic findings, the previous x-ray report, the history, or the operative findings, so that only an unequivocal defect was so called. Thus, in our hands the myelogram was the most accurate single factor in localization of the site of the lesion. Its value in demonstrating simultaneous multiple disk herniations and in aiding to reduce the number of unnecessary interspace explorations has been stressed by others and is supported by this report.

The surgical treatment employed in these cases was simple disk removal in the presence of disk herniation and simple exploration when no herniation was found. Spinal fusion was not performed as a routine procedure concomitant with disk removal, nor was it utilized in cases of negative exploration, as recommended by some. Spinal fusion was accomplished only when spondylolisthesis was also present, and this accounted for only 3% of the cases. Chordotomies and sensory nerve sections were not considered necessary in any patient. If a definite disk herniation was found at the level indicated by preoperative studies, the disk was removed and the procedure terminated. Exploration of addi-

tional interspaces in such situations, as recommended by Murphy,[24] was not accomplished.

The over-all results of surgical therapy in this series have been satisfactory. Attempts to correlate such factors as workmen's compensation, government pension, age, arthritis, and psychoneurosis with the end-results of treatment were not made. Certainly these play some part. Nevertheless, 92% of the patients with disk herniations felt that they were benefited by surgery, and 88% of the patients with negative explorations felt that they were benefited. Perhaps the improvement in the negative exploration group can be explained by the uncapping of the nerve root accomplished at the time of exploration. No appreciable variation in end-results was found when the group of disk herniations with an extruded free fragment was compared with that in which the posterior longitudinal ligament was intact. It is of interest that, although 12% of the patients with disk herniations and 23% of the patients with negative explorations said that they were now wearing a back brace part or all of the time, no patient has returned to us or said that he went elsewhere for a spinal fusion.

Conclusions

Satisfactory results are obtained when symptomatic lumbar disk protrusions not responding to conservative measures are surgically treated by simple disk removal without accompanying spinal fusion.

Chordotomy, rhizotomy, and spinal fusion are not indicated when exploration for a herniated lumbar intervertebral disk is negative.

The most valuable single procedure in localizing the level of disk herniation is myelography.

Narrowing of the L4-L5 interspace is not associated with disk herniations at any other level and is therefore a valuable localizing sign when present.

The end-results of surgical therapy in patients who exhibit a bulging posterior longitudinal ligament are the same as those in patients in whom the ligament has ruptured and disk material is extruded into the vertebral canal.

Dr. Paul J. Trier, chief of the Department of Radiology, and Dr. Thomas Ware, senior radiology resident, reviewed all of the x-rays. Dr. Thomas Glenchur, senior surgical resident, collected a portion of the clinical data.

Veterans Administration Center (9).

REFERENCES

1. Arbuckle, R. K.; Sheldon, C. H., and Pudenz, R. H.: Pantopaque Myelography: Correlation of Roentgenologic and Neurologic Findings, Radiology 45:356, 1945.

2. Barr, J. S.: Ruptured Intervertebral Disc and Sciatic Pain, J. Bone & Joint Surg. 29:429, 1947.

3. Caldwell, G. A., and Sheppard, W. B.: Criteria for Spine Fusion Following Removal of Protruded Nucleus Pulposus, J. Bone & Joint Surg. 30:971, 1948.

4. Campbell, E., and Whitfield, R. D.: Certain Reasons for Failure Following Disk Operations, New York J. Med. 47:2569, 1947.

5. Cloward, R. B.: Treatment of Ruptured Lumbar Intervertebral Discs: Criteria for Spinal Fusion, Am. J. Surg. 86:145, 1953.

6. Cloward, R. B.: Multiple Ruptured Lumbar Discs, Ann. Surg. 142:190, 1955.

7. Cloward, R. B.: Treatment of Ruptured Lumbar Intervertebral Discs by Vertebral Body Fusion: Indications, Operative Technique, After Care, J. Neurosurg. 10:154, 1953.

8. Compere, E. L., Editor: 1953-54 Year Book of Orthopedics and Traumatic Surgery, Editor's Notes, Chicago, Year Book Publishers, Inc., pp. 179; 181.

9. Davis, L.; Martin, J., and Goldstein, S. L.: Sensory Changes with Herniated Nucleus Pulposus, J. Neurosurg. 9:133, 1952.

10. Decker, H. G., and Brennan, J. E.: A Review of 50 Operated Cases of Protruded or Ruptured Intervertebral Discs in the Lumbar Areas, J. Iowa M. Soc. 41:215, 1951.

11. Echols, D. H.: Surgical Treatment of Sciatica, Arch. Neurol. & Psychiat. 61:672, 1949.

12. Echols, D. H., and Rehfeldt, F. C.: Failure to Disclose Ruptured Intervertebral Disks in 32 Operations for Sciatica, J. Neurosurg. 6:376, 1949.

13. Fairburn, B., and Stewart, J. M.: Lumbar Disc Protrusion as a Surgical Emergency, Lancet 2:319, 1955.

14. Ford, L. T.; Ramsey, R. H.; Holt, E. P., and Key, J. A.: An Analysis of 100 Consecutive Lumbar Myelograms Followed by Disc Operations for Relief of Low-Back Pain and Sciatica, Surgery 32:961, 1952.

15. Grantham, E. G., and Spurling, R. G.: Ruptured Lumbar Intervertebral Disks, M. Clin. North America 37:479, 1953.

16. Greenwood, J., Jr.; McGuire, T. H., and Kimbell, F.: A Study of the Causes of Failure in the Herniated Disc Operation—An Analysis of 67 Reoperated Cases, J. Neurosurg. 9:15, 1952.

17. Kane, C. A., and Lane, G. M.: The Diagnosis and Management of Herniated Discs, M. Clin. North America 39:1463, 1955.

18. Keegan, J. J.: Dermatome Hypalgesia Associated with Herniation of Intervertebral Disks, Arch. Neurol. & Psychiat. 50:67, 1943.

19. Kugelberg, E., and Petersen, I.: Muscle Weakness and Wasting in Sciatica Due to Fourth Lumbar or Lumbosacral Disc Herniations, J. Neurosurg. 7:270, 1950.

20. Leader, S. A., and Rassel, M. J.: Value of Pantopaque Myelography in Diagnosis of Herniation of Nucleus Pulposus in Lumbosacral Spine: Report of 500 Cases, Am. J. Roentgenol. 69:231, 1953.

21. Lindblom, K.: Technique and Results in Myelography and Disc Puncture, Acta radiol. 34: 321, 1950.

22. Love, J. G.: Disc Factor in Low-Back Pain With or Without Sciatica, J. Bone & Joint Surg. 29:438, 1947.

23. Mixter, W. J., and Barr, J. S.: Rupture of Intervertebral Disk with Involvement of the Spinal Canal, New England J. Med. 211:210, 1934.

24. Murphy, J. P.: Protrusion or Rupture of the Lumbar Intervertebral Disks, M. Ann. District of Columbia 24:277, 1955.

25. Parrella, G. S., and Zovickian, A.: Ruptured Intervertebral Disc Problem in the Veteran, Surgery 27:762, 1950.

26. Poppen, J. L.: Herniated Intervertebral Disc: Analysis of 400 Verified Cases, New England J. Med. 232:211, 1945.

27. Raaf, J., and Berglund, G.: Results of Operations for Lumbar Protruded Intervertebral Disc, J. Neurosurg. 6:160, 1949.

28. Ross, P., and Jelsma, F.: Postoperative Analysis of 366 Consecutive Cases of Herniated Lumbar Discs, Am. J. Surg. 84:657, 1952.

29. Scoville, W. B.; Moretz, W. H., and Hankins, W. D.: Discrepancies in Myelography, Surg. Gynec. & Obst. 86:559, 1948.

30. Scuderi, C.: Backache: Diagnosis and Treatment from Orthopedic Standpoint, Postgrad. Med. 15:301, 1954.

31. Shinners, B. M., and Hamby, W. B.: Protruded Lumbar Intervertebral Discs: Results Following Surgical and Non-Surgical Therapy, J. Neurosurg. 6:450, 1949.

32. Spurling, R. G., and Grantham, E. G.: The End Results of Surgery for Ruptured Intervertebral Discs, J. Neurosurg. 6:57, 1949.

33. Walker, E.; Miles, F. C., and Simpson, J. R.: Back Disability: 1930 to 1955, Am. Surgeon 21:1112, 1955.

34. Woolsey, R. D., and Tsang, J. L. K.: A Review of 300 Protruded Intervertebral Discs Treated Surgically, J. Internat. Coll. Surgeons 18:456, 1952.

Rectal Carcinoma Invading the Prostate Gland

EMIL J. GANEM, M.D.; DAVID W. WALLWORK, M.D.; LESLIE S. JOLLIFFE, M.D., and JULIUS KAY, M.D., Lawrence, Mass.

It is generally acknowledged that the two layers of the prostatoperitoneal fascia of Denonvillier, which lie as a transverse aponeurosis interposed between the posterior surface of the prostate and seminal vesicles and the anterior surface of the rectum seem to act as a protective barrier to neoplastic infiltration. Young,[1] in a study of 111 cases of primary prostatic carcinoma, observed only one instance in which invasion occurred through this fascia into the rectal mucosa with ulceration. Ackerman and del Regato,[2] in discussing primary rectal carcinoma, state that true invasion of the prostate occurs only rarely because "Denonvillier's fascia usually provides protective check to intraprostatic invasion."

At the same time, it is not a rare clinical experience in urological practice to encounter a patient two or three years following performance of an abdominoperineal resection for rectal carcinoma because of dysuria, hematuria, or symptoms of bladder-neck obstruction. Such a patient may prove after complete urological study to have secondary infiltration of the prostatic urethra, bladder neck, or bladder base from the rectal malignancy, and at once he becomes a candidate for treatment, which at best is merely palliative.

Oppenheimer [3] estimates that at least 10% of patients who have had an abdominoperineal resection for rectal carcinoma will develop late involvement of the bladder, prostate, or seminal vesicle, probably as a result of contiguous direct extension from residual cancer. In his analysis of 27 male patients who died with the diagnosis of carcinoma of the rectum and who had not had extirpative surgery, he found 14, or 51%, in whom autopsy showed involvement of the bladder, prostate, or seminal vesicles. He feels that this involvement is the result of direct extension, and, though metastasis to the bladder or prostate may theoretically occur, this must be very rare.

Stearns and Binkley,[4] in a study of 56 cases of recurrent rectal malignancy following abdominoperineal resection performed for primary lesions lying in the distal 6 cm. of the rectum, noted that 20 patients had distant metastases, while the remaining 36 patients developed local recurrence, chiefly along the lateral pelvic hypogastric vessels. They also stated that "in a number of males it [i. e., recurrence] occurred in the region of the prostate."

In the group of patients whose recurrence was noted five years or later following abdominoperineal resection for rectal carcinoma these authors observed that one-third of the recurrences were local in the pelvis and the remainder were due to distant metastases.

It would seem, therefore, that extended operations may at times be required in dealing with some rectal cancers because of their adherence to or involvement of surrounding structures. Since it is not always possible to determine at operation whether the adherence is inflammatory or neoplastic or both, one incurs the risk of leaving behind foci of malignant tissue which may become the seed of a future recurrence if the conservative abdominoperineal resection operation is rigidly adhered to in all instances.

Prohaska, Govostis, and Wasick,[5] in a report of 21 cases of rectal malignancy showing adherence to surrounding struc-

Submitted for publication Dec. 11, 1956.

From the Urological Service of the Lawrence General Hospital.

tures, were able to prove histopathologically in all cases that the cohesion between the primary lesion and the adjacent organ or structure was due to carcinomatous infiltration rather than to inflammation alone. In their series of 21 "extended operations" there were 5 men with rectal cancer, but in none of these was radical prostatectomy performed.

While the surgical morbidity and mortality of these extended operations are higher, the value of the procedure in selected instances of locally invasive disease without distant metastases cannot be questioned. Thus, Sugarbaker,[6] in studying 42 cases of extended operations, that is, abdominoperineal resection plus the resection of some other structures (uterus, bladder, prostate, and small intestine), reported an operative mortality of 19%, as compared with a mortality of 9% for the conventional abdominoperineal resection. However, the duration of postoperative survival appeared to justify the procedure. In Sugarbaker's series there were eight patients in whom the "retrourethral prostate and seminal vesicles" were removed, but in only two of these was malignant invasion demonstrated. One of these died 12 days postoperatively of intestinal obstruction, and the second was reported as "well after 2 months."

Dunphy,[7] in discussing radical operations for recurrent cancer of the colon and rectum, reported four patients, of whom one was a man who developed a perineal recurrence eight months following abdominoperineal resection for rectal carcinoma. Fourteen months later a radical perineal excision of this recurrent tumor along with total prostatectomy was performed, and the patient remained asymptomatic except for urinary incontinence for four years, though a second perineal recurrence developed. Dunphy felt that radical surgery for locally recurrent cancer may at times be justified when there is no evidence of distant metastasis because of surprising prolongation of life that may follow such procedures.

The case report of a patient with histopathologic evidence of rectal carcinoma invading the prostate follows. Operative treatment consisted of a one-stage abdominoperineal resection combined with a radical perineal prostatectomy and bilateral seminal vesiculectomy, such as is recommended by Young[8] for early primary prostatic carcinoma. A five-year follow-up shows him to be free of demonstrable recurrent disease and to have perfect urinary control.

Report of a Case

A 66-year-old, retired fireman was admitted April 14, 1951, to the hospital with a 14-month history of intermittent rectal bleeding, with frequent loose bowel movements and pain in the perineum. There had been a 40 lb. weight loss two years previously as a result of deliberate dieting. There were no urinary symptoms.

The past history was negative.

Physical examination showed a well-developed man with evidence of recent loss of weight. There was no visible jaundice. There was no palpable supraclavicular, axillary, or inguinal lymphadenopathy. Lungs were clear. Heart was negative. Blood pressure was 140/80. No masses could be felt in the abdomen. The liver was not palpably enlarged. External genitalia were not remarkable. Rectal examination revealed normal anal sphincter tone. A soft, friable mass, measuring about 4 cm. in diameter, could be felt in the anterior wall of the rectum. Only the apex of the prostate could be felt, the remainder of the gland being inaccessible to the examining digit because of the presence of this mass, which was not movable, but fixed, and bled easily on examination. There was no peripheral edema. Neurologic examination was negative.

Laboratory studies showed the urine to be negative for albumin and glucose. Sediment showed an occasional white blood cell and 3 to 5 red blood cells per high-power field. The specific gravity was 1.030. The red blood cell count was 4,750,000; the white blood cell count was 5700 per cubic millimeter. The hemoglobin was 13.7 gm. per 100 cc. The nonprotein nitrogen was 41 mg. per 100 cc. Fasting blood sugar was 97 mg. per 100 cc. Total protein was 4.8 gm. per 100 cc. The Hinton test was negative.

An intravenous pyelogram was normal except for evidence of Paget's disease involving the right innominate bone. The barium enema showed no evidence of any lesion in the large bowel other than the solitary rectal neoplasm. Cystoscopy showed no evidence of invasion of the bladder base or ulceration of the prostatic urethral epithelium.

Fig. 1.—Low-power photomicrograph of the edge of the ulcerating adenocarcinoma of the rectum. Note deep invasion of muscularis by atypical gland acini.

Rectal biopsy was reported as showing adenocarcinoma of the rectum. On April 17 a combined abdominoperineal resection was performed under continuous spinal anesthesia, supplemented by nitrous oxide, oxygen, and ether by inhalation. Exploration revealed no palpable or visible metastases in the liver. In the perineal part of the operation, a radical perineal prostatectomy and bilateral seminal vesiculectomy (Young's operation) was performed, and the entire prostate, both seminal vesicles, and bladder neck were removed, along with the rectum. The urinary bladder was then anastomosed to the membranous urethra. The operative procedure was complicated by the fact that the suture of the peritoneal floor gave way during the perineal dissection, necessitating reopening of the abdominal wound to effect a competent closure of the peritoneal floor. The patient received 4 pt. (2000 cc.) of blood by transfusion. The duration of the operation was three and one-half hours. The pathologic report of the specimen showed it to be adenocarcinoma of the

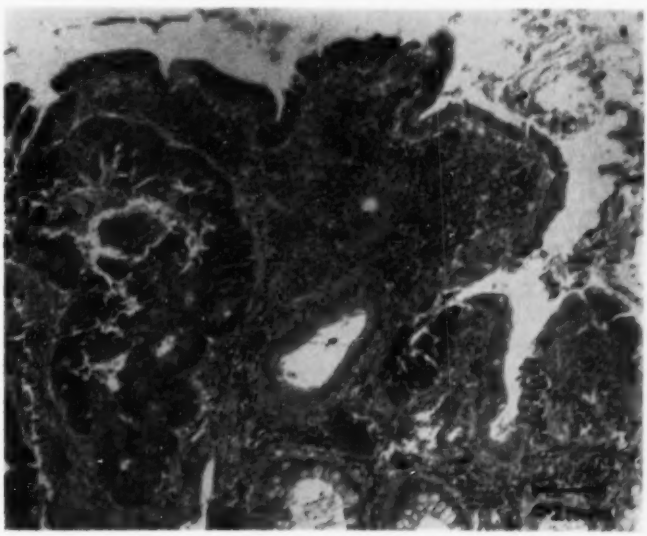


Fig. 2.—High-power view of area outlined by rectangle in Figure 1. Note junction of normal and carcinomatous epithelium.

Fig. 3.—Low-power photomicrograph of prostatic specimen. Prostatic parenchyma to the left; Denonvillier's fascia at *C*; recanalized thrombosed vein of prostatic plexus at *V*.

rectum (Figs. 1 and 2), invading the muscularis and serosa of the rectal wall and also invading the prostate (Figs. 3 and 4). The seminal vesicles were free of microscopic evidence of invasion by carcinoma.

The postoperative course was afebrile and smooth. He was discharged from the hospital on the 18th postoperative day with a well-functioning colostomy and with good urinary control.

Follow-up examination on Aug. 23, 1956, five and one-third years later, showed him to be in excellent health, with a well-functioning colostomy and perfect urinary control. The physical examination was completely negative for evidence of recurrent carcinoma.

Summary and Conclusions

At times rectal carcinoma may spread locally to involve the prostate or seminal vesicles without producing distant, nonresectable metastases.

In such instances it would appear to be surgically feasible to combine radical perineal prostatectomy and bilateral seminal vesiculectomy with the conventional abdominoperineal resection in order to enhance the chance of complete eradication of the malignant disease.

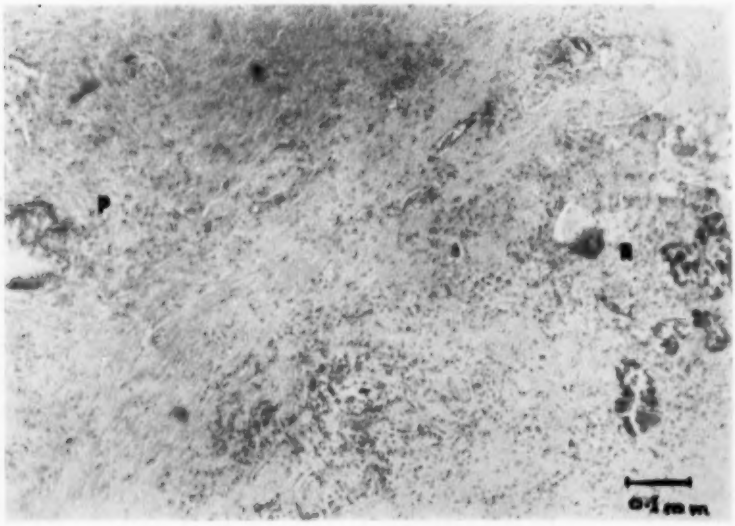
A case report is presented which illustrates a successful five-year survival of such a patient with freedom from demonstrable disease and with normal urinary control.

301 Essex St. (Dr. Ganem).

REFERENCES

1. Young, H. H., in Modern Urology, edited by Hugh Cabot, Ed. 2, Philadelphia, Lea & Febiger, 1924, Vol. I, Chap. XIX.

Fig. 4.—High-power view of area outlined by rectangle in Figure 3. A peripheral prostatic gland acinus at *P* and the "vanguard" of invading rectal carcinoma at *R*.



2. Ackerman, L. V., and del Regato, J. A.: Cancer: Diagnosis, Treatment and Prognosis, St. Louis, The C. V. Mosby Company, 1947, Chap. 10, pp. 573-610.

3. Oppenheimer, G. D.: Late Invasion of the Bladder and Prostate by Carcinoma of the Rectum or Sigmoid, J. Urol. 54:162-166, 1945.

4. Stearns, M. W., Jr., and Binkley, G. E.: The Influence of Location on Prognosis in Operable Rectal Cancer, Surg. Gynec. & Obst. 96: 368-370, 1953.

5. Prohaska, J. V.; Govostis, M. C., and Wasick, M.: Multiple Organ Resections for Advanced Carcinoma of the Colon and Rectum, Surg. Gynec. & Obst. 97:177-182, 1953.

6. Sugarbaker, E. D.: Coincident Removal of Additional Structures in Resections for Carcinoma of the Colon and Rectum, Ann. Surg. 123:1036-1046, 1946.

7. Dunphy, J. E.: Recurrent Cancer of the Colon and Rectum: Report of Cases with Favorable Results Following Radical Surgery, New England J. Med. 237:111-113, 1947.

8. Young, H. H.: The Early Diagnosis and Radical Cure of Carcinoma of the Prostate: Being a Study of 40 Cases and Presentation of a Radical Operation Which Was Carried Out in 4 Cases, Johns Hopkins Hosp. Bull. 16:315-331, 1905.

Polyps of the Colon in Children

DONALD L. GORDON, M.D.; GEORGE A. HALLENBECK, M.D.; MALCOLM B. DOCKERTY, M.D.; ROGER L. J. KENNEDY, M.D., and RAYMOND J. JACKMAN, M.D., Rochester, Minn.

Adenomatous polyps of the colon are sessile or pedunculated, and single or multiple. If multiple, they may be few and scattered or so numerous and diffuse that they virtually replace the lining of the colon. The most significant feature of polyps of the colon in adults is the fact that they are known precursors of adenocarcinoma. From this fact stems the generally accepted view that colonic polyps in adults should be removed. Although adenomatous polyps sometimes occur in the colons of children, carcinoma of the colon is rare in pediatric practice. Gross, with the considerable experience of the Children's Hospital in Boston at his disposal, describes only one case, that of a girl 12 years of age, who had polyposis of the colon associated with an adenocarcinoma of the rectum. The present study of colonic polyps in children was carried out in the hope that data might emerge to guide us in the treatment of these lesions in young patients.

Materials and Methods

A review was made of the case histories from the years 1907 to 1953, inclusive, of all children up to 15 years of age who were found at the Mayo Clinic to have polypoid lesions of the large intestine. Excluded were all cases of chronic ulcerative colitis, intestinal parasites, fibroma, myoma, hemangioma, granuloma, lymphoid polyp, and lymphoma. Only the cases of adenomatous polyps were retained, and of these there were 104.

In 46 cases tissue was not available for study, either because the polyps had been destroyed by fulguration or because treatment had been refused or had been carried out elsewhere. From 58 cases of the 104, specimens had been preserved in 10% formalin, and microscopic sections made at the times of the original operations were available also. For further microscopic examination of these specimens, additional blocks were cut and prepared which included adjacent tissues of colon, lymph nodes, and stalks of polyps when these were present. Usually, however, only the polyp and its stalk had been removed, and adjacent colonic tissue and nodes therefore could not be examined.

For purposes of evaluation, the 104 patients were divided into three groups: (1) 6 patients with diffuse polyposis (myriads of polyps); (2) 8 patients with from 10 to 100 polyps (probably the same disease as that of patients in Group 1), and (3) 90 patients with from 1 to 9 polyps.

Observations

Incidence.—When the five-year period of 1944 through 1948 was used to obtain an estimate of the incidence of adenomatous polyps diagnosed at the Mayo Clinic, it was found that about 1 child in every 1500 pediatric admissions, or approximately 0.07%, had adenomatous polyps demonstrable in the colon. With exclusion of the newborn infants, this figure becomes just less than 0.1%.

Sex and Age.—There were 60 male and 54 female patients in the group, a ratio of approximately 1.1:1. Of the 104 patients, 79 were children from 2 to 6 years of age. The youngest child was a boy 13 months of age.

Family History.—A convincing familial history of colonic disease was obtained in only one of the six cases of diffuse poly-

Submitted for publication Jan. 23, 1957.

Abridgment of thesis submitted by Dr. Gordon to the Faculty of the Graduate School of the University of Minnesota in partial fulfillment of the requirements for the degree of Master of Science in Surgery.

Fellow in Surgery, Mayo Foundation (Dr. Gordon); Section of Surgery (Dr. Hallenbeck); Section of Surgical Pathology (Dr. Dockerty); Section of Pediatrics (Dr. Kennedy); Section of Proctology (Dr. Jackman), Mayo Clinic and Mayo Foundation. The Mayo Foundation, Rochester, Minn., is a part of the Graduate School of the University of Minnesota.

posis. This child's father, paternal grandfather, and paternal uncle all had died of cancer of the colon between the ages of 29 and 32 years.

Three of the eight patients with more than 9 but fewer than 100 polyps presented evidence of familial disease. One had a 3-year-old brother with polyps; the second had a first cousin with the disease, and the mother of the third had colonic polyps.

Of the 90 patients with fewer than 10 polyps, 3 had relatives who were known to have had the disease, and 4 more had older relatives who had died of carcinoma of the colon.

Thus a history of colonic polyps in other members of the family was much more frequent when the patients had many polyps than when few polyps were present. The true incidence could be higher than the data indicate, since we did not have the opportunity to examine other members of most of these families and could learn only of those with polyps known to the children's parents or guardians.

Symptoms and Signs.—Passage of bright red blood with feces or after bowel movements was the commonest finding and was present in 99 of the 104 cases. In the five cases without this finding the polyps were discovered during routine examination. Bleeding severe enough to be called "hemorrhage" was described by the parents of only four patients; two of these patients had required blood transfusions before their visit to the clinic.

Other signs and symptoms less consistently found were passage of excessive mucus with the stools (30 patients), prolapse of polyps through the anus (19 patients), vomiting (6 patients), abdominal pain or cramps (29 patients), and diarrhea (26 patients). Diarrhea occurred more commonly in patients with many polyps (8 of 14) than in those with few (18 of 90). In several patients the parents had noticed passage of fleshly masses, presumed, and sometimes proved, to be polyps which had become detached from the colon.

Physical Examination.—Digital examination of the rectum was performed on all patients; rectal polyps were palpated in 17 of the 104.

The association of pigmented spots around the lips, in the oral mucosa, and about the digits with polyps of the colon, and often the small intestine and the stomach, has been termed "Peutz-Jeghers syndrome."[2] It is of rare occurrence, and during most of the years covered by this study was not sought or discovered. From 1950 to 1953, comments were made in the records of the 11 patients seen that such pigmented spots were not present.

No other physical abnormalities were encountered which seemed related to the colonic polyps.

Laboratory Investigation.—The hemoglobin in the blood in only 3 of the 93 cases in which determinations were available was considered subnormal by ordinary standards. Only one child of the three was said to have had a rectal hemorrhage.

Leukocytosis was observed in 13 of 92 cases checked. Among the differential leukocyte counts made in 47 cases, none was considered abnormal.

Diagnostic Examination.—Proctoscopic examinations were carried out in 103 of the 104 cases. Seventy-eight of these examinations (75%) disclosed rectal or sigmoidal polyps.

Colonic roentgenograms were made for 92 patients at the clinic, and 2 patients presented roentgenograms which had been made elsewhere. Of these, 62 (66%) showed colonic polyps.

Pathologic Features.—Gross Characteristics: Adenomatous polyps seen in this series varied in size from 1 mm. elevations on the mucosa to masses 5 cm. in diameter, usually on a pedicle. The pedicles varied from 1 mm. to several centimeters in length.

One hundred sixty-one adenomas were identified in the group of 90 patients who had fewer than 10 polyps. Their distribution throughout the large bowel was as fol-

lows: cecum, none; ascending colon, 2; hepatic flexure, 5; transverse colon, 15; splenic flexure, 6; descending colon, 15; sigmoid colon more than 24 cm. from the anal verge, 36, and the terminal 24 cm. of the bowel, including the rectum, 82. Thus, assuming that polyps within 24 cm. of the anal verge can be fulgurated proctoscopically, 51% of all polyps seen in children who had fewer than 10 of them could be treated by this method.

Microscopic Data: The microscopic picture of benign adenoma featured a glandular pattern which was well differentiated and appeared to depart but little from the picture of normal mucosa. Goblet cells were numerous, and nuclei were small and basally located. Inflammatory changes were found consistently. Microhemorrhages were fairly common, as was microcystic expansion of some glandular spaces. Infiltrated eosinophils were seen in a few cases.

The criteria considered necessary for a diagnosis of malignancy were (1) stratification of epithelial cells with hyperchromatic nuclei, (2) mitotic activity, (3) absence of goblet cells, and (4) presence of large nucleoli. The occurrence of any three of these was considered sufficient for the diagnosis of malignancy in an adenoma. In nine patients one or more polyps fulfilled these criteria and were considered to contain carcinoma in situ. Of greater importance is the observation that invasive carcinoma was not encountered in any of the 58 cases from which polyps could be examined nor suggested by questionnaires returned in 35 more.

The colon adjacent to both the benign and the malignant polyps was always normal among the specimens present for study. All lymph nodes examined were normal. The adjacent ileum showed lymphoid hyperplasia, as did the appendices when available for microscopic examination.

Treatment.—Removal of polyps was advised regularly, and only occasionally was refused by the patient's parents or guardian. Ninety-three of the 104 children received some form of treatment. Polyps within reach of the sigmoidoscope were fulgurated. In 34 instances laparotomy was performed so that polyps could be removed transcolonically. Segmental resection of the colon was performed twice, and subtotal colectomy with ileosigmoidostomy was carried out six times.

Follow-Up Findings.—Forty patients returned to the clinic for further examination after the polyps initially found had been removed, and new or previously unrecognized polyps were found in 18 of them. In 7 of these 18 patients, the second examination was made only 1 year after the first; the longest interval between the initial and subsequent examinations was 13 years. Of the six patients with diffuse polyposis, three were reexamined, and in each of them additional polyps were discovered. Of the eight patients who were found to have from 10 to 100 polyps at their first examination, seven were studied subsequently, and all were found to have additional polyps. Of the 90 children who were considered initially to have from one to nine polyps, 30 were reexamined and 8 were found to have additional polyps; in 3 of these, between 10 and 100 polyps were present.

Principles of Treatment

To understand thoroughly the prognosis for children with adenomatous polyps of the colon and rectum, one would need to follow many such patients for the duration of their lives. Compared with this ideal, the data we have been able to assemble are indeed fragmentary. Taken with other information in medical literature, however, they permit development of a realistic approach toward treatment of the disease.

Fundamental Distinctions.—First, it is clear that some children have diffuse polyposis of the colon which is sometimes, but not always, familial, and that if they are untreated, carcinoma of the colon is virtually certain to develop later, sometimes even early in adulthood. Second, it is equally clear that some children present

an isolated polyp or a few polyps and have no tendency toward diffuse polyposis during several years of observation. Whether after removal of the polyp or polyps carcinoma of the colon is anymore likely to develop in later life in these patients than in persons who never had even one polyp, we do not know. In the state of our present knowledge, it seems best to consider them different from the smaller group of patients with diffuse polyposis. Third, our data indicate that a few children in whom diffuse polyposis of the colon is destined to develop may initially be thought to have only a few polyps, either because others have not yet begun to develop or because many polyps are too small to be recognized at first.

Diffuse Polyposis.—If a child has diffuse polyposis of the colon or has many polyps scattered through the colon and rectum, it is evident that the lesions cannot be removed individually with any hope of complete success and that extensive colectomy will be needed to control the disease. If the concern is only with the danger of cancer, a good case can be made for removal of the entire rectum and colon and ileostomy. The difficulties of life with an ileac stoma are formidable, however, and, despite the fact that many patients make a satisfactory adjustment to it, an ileac stoma constitutes a disability. Quite apart from the inconvenience of caring for the stoma, complications such as prolapse, stricture, or fistula occur in many instances and may require further operations to revise the ileac stoma. These considerations have led many, including ourselves, to prefer subtotal colectomy with ileorectosigmoidostomy, and reliance on regular proctoscopic examinations and fulguration when needed to keep the rectum and remaining rectosigmoid free of polyps. This position has been discussed fully by Smith and Jackman.

Occasionally adult patients are seen who have rectal polyps so confluent that no normal-looking mucosa appears between them. Thus far we have not encountered this situation in children, but there is no reason to believe it cannot occur. In such a case, total colectomy with ileostomy would probably be the best treatment.

When one proposes to preserve the terminal segment of the bowel and control the polyps therein by fulguration, he accepts the risk that cancer may develop despite his efforts and assumes that this risk is outweighed by the alternative risk and serious inconvenience attendant on an ileostomy. When the diseased rectum deliberately is left in place, the responsibility assumed by the physician, the child's family, and later the patient himself is great indeed. The physician must see that the family and, when he is old enough, the patient understands clearly that new polyps may form at any time for the duration of life and that proctoscopic examinations to seek out and fulgurate new polyps must be made every six to nine months indefinitely. The price of laxity can be development of carcinoma of the rectum.

Once subtotal colectomy definitely is indicated, there is ordinarily no reason for delay. Even when the operation is performed on children 5 or 6 years of age, growth and development progress normally. It is well to remove as little of the ileum as possible, since, as Lillehei and Wangensteen have shown, diarrhea is more likely to occur if extensive resection of ileum is performed. The anastomosis between ileum and rectosigmoid should be made end-to-end, because a side-to-side anastomosis leaves a cul-de-sac of rectosigmoid which is difficult to examine properly and to clear of polyps by the proctoscopic approach.

The question arises: Which should be done first, the subtotal colectomy or the fulguration of polyps in the rectum and rectosigmoid? Occasionally severe bleeding or, in adults, the presence of carcinoma of the colon proximal to the site of the needed fulguration may demand that subtotal colectomy be done first. When this order of events is followed, the polyps in the terminal segment of the bowel can be fulgurated postoperatively. In general, however,

we prefer to fulgurate the polyps before subtotal colectomy whenever possible, because it is often difficult to expose all of the polyp-bearing mucosa at the site of anastomosis in the early postoperative period and because abdominal tenderness makes manipulation of the proctoscope more difficult if the procedure is carried out soon after operation. When fulguration is done first, it is wise to allow passage of six to eight weeks before colectomy so that the inflammatory reaction associated with fulguration will recede.

Because of the frequency with which this disease is familial, other members of the families of children with polyposis of the colon should be examined with the proctoscope and by roentgenograms of the colon for their protection.

Cases of Single or Few Polyps.—Patients with a single polyp or a few polyps present a different problem. All such polyps within reach of the proctoscope should be fulgurated. Polyps above this level require laparotomy. Transcolonic excision is adequate for the isolated pedunculated polyp, or even two or three, provided the surgeon is as certain as possible that they are not a part of more diffuse disease; the sessile polyp requires segmental resection of the part of the colon that bears it.

One of our patients illustrates a situation to be avoided. This child, 3 years old when first seen, underwent transcolonic removal of a polyp of the sigmoid at that time and transcolonic resection of two polyps from the ascending colon and one from the hepatic flexture six years later, only to require subtotal colectomy with ileorectosigmoidostomy for diffuse polyposis three years after that. A few rectal polyps were fulgurated from time to time as well. On each occasion, it was thought that all known polyps were being eliminated.

To avoid many operations when one would suffice, one must keep in mind that a few recognizable polyps, perhaps as few as 4 or 5, and certainly as many as 10, scattered throughout the colon and rectum, may mean that diffuse polyposis is developing. It is difficult to assign an arbitrary number of polyps beyond which the surgeon should abandon conservative measures and perform subtotal colectomy. We believe that the radical operation should be used more frequently than heretofore, and we plan definitely to employ it when more than five or six polyps are found scattered throughout the colon and rectum.

Advisability of Deferring Diagnosis.—When a few polyps, some of which are above the region accessible to the proctoscope, are found in young children, it sometimes will prove wise to defer laparotomy for a few years to observe the progress of the disease; the colon and rectum should be examined at intervals in order to arrive at an accurate diagnosis between isolated polyps and incipient diffuse polyposis. Adenomatous polyps of the colon must be removed ultimately because they can become malignant. However, the data indicate that invasive malignancy originating from colonic polyps is rare in children before puberty. We did not encounter a single case of carcinoma of the colon among 58 children less than 15 years of age whose colonic polyps could be studied microscopically, or among 35 more for whom questionnaires were answered. Only nine of these patients had polyps considered to show carcinoma in situ. Gross' unusual patient with polyposis of the colon in whom carcinoma of the rectum developed at the age of 12 years has been mentioned already, and McKenney has reported death from carcinomatosis in a 15-year-old child with polyposis of the colon. Later, even in the ages from 16 to 20 years, reports of carcinoma of the colon among patients with polyposis are more frequent. One can conclude that the threat of malignancy in children with colonic polyps is less immediate than in patients more than 15 years of age. Therefore, so far as malignancy is concerned, one can be deliberate in observation of children with polyps if this course is desirable in individual cases. In a few

instances, symptoms such as excessive bleeding, pain, diarrhea, and the like, may favor more immediate intervention, but in most a period of observation will be well tolerated. In all cases, it is safest to have removed the polyps by the time the child reaches the age of 15 years.

Summary

Clinical data have been presented concerning 104 children less than 15 years of age who were found at the Mayo Clinic to have adenomatous polyps of the colon. Polyps of the colon may become malignant and should be removed before this occurs. Diffuse, often familial polyposis of the colon evidently differs in significance from the presence of a single polyp or very few polyps. For the former condition, definitive treatment of choice consists of subtotal colectomy with ileorectostomy and fulguration of rectal polyps. For the latter, removal of the polyp or polyps may suffice. Occasionally, it may be difficult to decide whether a child merely has a few isolated polyps or is beginning the development of diffuse polyposis. Since carcinoma of the colon is so rare among children less than 15 years of age that none was encountered in this series of patients, the progress of the disease sometimes can be observed for a few years before the decision is made whether the surgical treatment should be limited or radical. It is safest to remove all known polyps by the time a child is 15 years of age.

40 East 61 St., New York (Dr. Gordon).

REFERENCES

1. Gross, R. E.: The Surgery of Infancy and Childhood, Philadelphia, W. B. Saunders Company, 1953, p. 302.

2. Jeghers, H.; McKusick, V. A., and Katz, K. H.: Generalized Intestinal Polyposis and Melanin Spots of the Oral Mucosa, Lips and Digits, New England J. Med. 241:993-1005 (Dec. 22) 1949.

3. Lillehei, R. C., and Wangensteen, O. H.: Bowel Function After Colectomy for Cancer, Polyps, and Diverticulitis, J. A. M. A. 159:163-170 (Sept. 17) 1955.

4. McKenney, D. C.: Multiple Polyposis: Congenital, Heredofamilial, Malignant, Am. J. Surg. 46:204-216 (Oct.) 1939.

5. Smith, W. G., and Jackman, R. J.: Polyposis of the Large Intestine: Preservation of the Terminal Segment, Am. J. Surg. 90:751-760 (Nov.) 1955.

Effect of Fibrinolytic Agents and Corticosteroid Hormones on Peritoneal Adhesions

A Comparative Experimental Study

EDMUND M. LUTTWAK, M.D.; ALBERT J. BEHAR, M.D., and NATHAN J. SALTZ, M.D., Jerusalem

Assuming that peritoneal adhesions result from the organization of an exudate between opposed peritoneal surfaces, their prevention may be approached either by attempts to destroy the deposited fibrin or by inhibiting its organization into connective tissue. For the former, activators of fibrinolytic enzymes have been used in experimental animals and have been shown to have an inhibitory effect on the development of peritoneal adhesions.[1-3] In a previously published experiment by one of us [2] the results suggested that streptokinase-streptodornase (SK-SD) exerted its effect before morphological reactions were histologically visible. For the latter, cortical steroids have been widely used in experimental animals and have been shown to have a favorable effect in inhibiting the formation of peritoneal adhesions.[4-6]

The present experiment was initiated in order to study the quantitative and qualitative effects of these different substances on talc-induced intraperitoneal adhesions and granulomas. Because of the wide variety of experimental animals and experimental conditions in various published works, satisfactory comparison of their end results is difficult. It was therefore determined to apply the experiment to groups of similar animals, under identical experimental conditions, in order to achieve satisfactory comparison.

Submitted for publication July 15, 1956.

This study was aided by a grant from the Nathan and Hilda Zlotoporo Fund.

From the Department of Surgery and Pathology, Rothschild-Hadassah-University Hospital, and the Hebrew University-Hadassah Medical School.

Material and Methods

White rats, male and female, ranging in weight from 150-250 gm., were used. The animals were kept under routine laboratory conditions. Three main experiments were carried out:

EXPERIMENT 1.—Thirty-six white rats were injected intraperitoneally with 1% talc suspension (in distilled water) in a dose of 10 mg. of talcum per 100 gm. of body weight. The animals were then divided into 3 groups of 12 rats each—one control and 2 experimental.

Group A.—Control: Received a second intraperitoneal injection of 2 cc. isotonic saline per 100 gm. of body weight.

Group B.—Received plasminogen intraperitoneally in a single dose of 2 cc. per 100 gm. body weight. Plasminogen was prepared by the modified Milstone method, from human serum.[7] In fact, this group served as a second control for Group C.

Group C.—Received 2 cc. plasmin per 100 gm. body weight intraperitoneally, in a single dose. The plasmin (fibrinolysin) was prepared by activating plasminogen with SK-SD* as described by Clifton[7,8]; 1000 units of SK and 250 units of SD were present in each 1.1 ml. of plasmin solution. All the animals were killed on the eighth day after injection.

EXPERIMENT 2.—Twenty-four white rats were injected intraperitoneally with talc suspension in a dose of 10 mg. per 100 gm. of body weight. The animals were then divided into four groups of six rats each, one control and three experimental.

Group A.—The control animals received a second intraperitoneal injection of 0.5 cc. of isotonic saline per 100 gm. body weight.

Group B.—Received intraperitoneally 0.5 cc. of isotonic saline per 100 gm. body weight, and after this a daily subcutaneous injection of 0.5 mg. of cortisone sulfate per 100 gm. of body weight,

* The Streptokinase-Streptodornase (Varidase) was supplied by Lederle Laboratory Division, American Cynamid Company, New York.

TABLE 1.—*Number of Peritoneal Granulomas and Adhesions Eight Days After Administration of Talc* (Experiment 1)

Rat No.	Control		Human Plasminogen-Treated		Plasmin-Treated (Activated with SK-SD)	
	Granulomas	Adhesions	Granulomas	Adhesions	Granulomas	Adhesions
1	40	0	34	3	15	3
2	32	2	29	2	23	2
3	38	1	38	0	21	2
4	25	1	* died 5th day		10	2
5	20	3	39	1	28	0
6	39	0	50	2	25	1
7	29	1	0	0	14	1
8	0	0	34	1	17	3
9	0	0	26	0	7	3
10	32	2	0	0	0	0
11	24	2	32	2	17	2
12	25	0	23	0	0	0
Total	304	12	305	11	177	18
Average	25.3	1	27.7	1	14.7	1.5

* This experiment was repeated, with daily intraperitoneal injections of plasmin, through eight days, but no differences were found in comparison with data above.

during eight days (a total of 4 mg. cortisone per 100 gm. of body weight).

Group C.—Received 4 mg. of cortisone per 100 gm. of body weight in a single dose, intraperitoneally. Every 4 mg. of cortisone was diluted in 0.5 cc. of isotonic saline.

Group D.—Received 4 mg. of hydrocortisone acetate per 100 gm. of body weight (suspended in 0.5 cc. of isotonic saline) by a single intraperitoneal injection. All the animals were killed after eight days.

EXPERIMENT 3.—Twenty-three were laparotomized under ether anesthesia, and talc, as dry powder, was introduced into the abdominal cavity in an amount of 10 mg. per 100 gm. of body weight.

The animals were divided in three groups, and the results compared with a previously published experiment by one of us[2] done under completely identical conditions, in which the effect of SK-SD in peritoneal adhesions were studied.

Group A.—Eight rats received at the time of laparotomy 5 mg. of hydrocortisone acetate in a suspension of 1 cc. of saline per 100 gm. of body weight intraperitoneally. The animals were killed on the eighth postoperative day.

Group B.—Nine rats received 5 mg. of hydrocortisone acetate in 1 cc. of isotonic saline per 100 gm. of body weight intraperitoneally at the time of laparotomy, and each of them was killed at two- to three-day intervals up to 21 days after operation.

Group C.—Six rats received at the time of laparotomy a single dose of hydrocortisone acetate intraperitoneally which ranged from 1 to 6 mg. per 100 gm. of body weight. All the animals were killed on the eighth postoperative day.

At autopsy the number and size of granulomas, the number of intraperitoneal adhesions, and the number of adhesions to the suture line were recorded. Segments of bowel and viscera with granulomas and adhesions and mesenteric lymph nodes were removed and place in 4% formaldehyde fixative. The tissues were sectioned and stained with hematoxylin-and-eosin, Van Gieson's method, and Laidlaw's method for reticulin.

Results

Table 1 shows the results of Experiment 1. Plasminogen and plasmin had no inhibitory effect on adhesions. However, those animals receiving plasmin developed about

TABLE 2.—*Number of Peritoneal Granulomas and Adhesions Eight Days After Administration of Talc* (Experiment 2)

Rat No.	Controls		Cortisone-Treated by Subcutaneous Injection		Cortisone-Treated, Intraperitoneally		Hydrocortisone-Treated, Intraperitoneally	
	Granulomas	Adhesions	Granulomas	Adhesions	Granulomas	Adhesions	Granulomas	Adhesions
1	23	2	27	1	32	0	14	0
2	37	2	32	3	33	0	15	0
3	24	4	31	1	0	0	0	0
4	11	1	32	0	8	1	5	0
5	22	1	36	1	9	0	11	0
6	27	2	0	0	11	0	13	0
Total	144	12	158	6	93	1	58	0
Average	24	2	26.3	1	15.5	0.1	9.6	0

TABLE 3.—*Number of Peritoneal Adhesions and Granulomas Eight Days After Administration of Talcum* (Experiment 3, Group A)

Rat	Controls*			SK-SD-Treated			Hydrocortisone-Treated		
No.	Granulomas	Peritoneal Adhesions (Other Than to Suture Line)	Adhesions to Suture Line	Granulomas	Peritoneal Adhesions (Other Than to Suture Line)	Adhesions to Suture Line	Granulomas	Peritoneal Adhesions (Other Than to Suture Line)	Adhesions to Suture Line
1	22	1	3	3	0	2	1	0	0
2	57	3	1	26	1	1	3	0	1
3	29	3	1	3	2	1	3	0	0
4	20	1	1	1	0	1	5	0	0
5	16	4	1	0	0	0	2	1	1
6	1	4	1	1	0	1	3	0	0
7	19	1	1	9	0	0	5	0	0
8	38	3	1	8	0	1	2	0	0
Total	202	20	10	51	3	7	24	1	2
Average	25.2	2.5	1.2	6.5	0.4	0.9	3	0.1	0.2

* From previously published experiment.[1]

half the number of granulomas as the control or plasminogen-treated groups. The experiment repeated with daily injections of plasmin, for eight days, revealed no difference in result.

In Table 2 are presented data of animals treated with cortical steroids. No differences from the control group were seen in animals treated with cortisone subcutaneously. Those animals treated with cortisone intraperitoneally showed a marked reduction in granuloma formation, and only a single animal in this group developed adhesions. Those animals treated with hydrocortisone intraperitoneally showed an even more marked reduction of granulomas and none of this group developed adhesions.

Macroscopic observation revealed that the granulomas present in animals treated intraperitoneally with cortisone and hydrocortisone were tiny and white in color, covered by smooth serosa, and easily detached from their base. Granulomas in the control group were more than 1.5 mm. in diameter, yellow in color, and firmly organized. The single adhesion present in the cortisone- and hydrocortisone-treated group was a thin filmy thread. In the controls adhesions were firm fibrous bands.

Table 3 represents animals given 5 mg. of hydrocortisone intraperitoneally and killed after eight days. The data shows only a few granulomas and a single adhesion in one animal. Two animals showed adhesions

TABLE 4.—*Number of Peritoneal Granulomas and Adhesions at Varying Time Intervals After Administration of Talc* (Experiment 3, Group B)

Rat	Controls*			SK-SD-Treated*			Hydrocortisone-Treated		
Day Killed	Granulomas	Peritoneal Adhesions (Other Than to Suture Line)	Adhesions to Suture Line	Granulomas	Peritoneal Adhesions (Other Than to Suture Line)	Adhesions to Suture Line	Granulomas	Peritoneal Adhesions (Other Than to Suture Line)	Adhesions to Suture Line
2	3	1	1	2	0	1	0	0	0
4	46	0	1	5	0	1	4	0	0
6	20	1	1	1	0	1	6	0	0
8	19	1	1	0	0	0	2	0	0
10	49	4	0	26	3	1	5	0	1
13	52	3	1	10	1	1	3	0	1
15	38	4	1	11	3	1	4	0	1
18	27	0	1	31	1	1	3	0	1
21	43	3	1	25	0	2	8	0	1
Total	297	17	8	111	8	9	35	0	5
Average	33	1.9	0.9	12.3	0.9	1	3.9	0	0.5

* From previously published experiment.[1]

TABLE 5.—*Number of Peritoneal Adhesions and Granulomas Eight Days After Administration of Talc; Varying Doses of Hydrocortisone* (Experiment 3, Group C)

		Hydrocortisone-Treated		
Rat	Dose per 100 Gm. Body Wt., Mg.	Granulomas	Peritoneal Adhesions (Other Than to Suture Line)	Adhesions to Suture Line
1	1	16	1	1
2	2	6	0	0
3	3	8	0	1
4	4	9	0	1
5	5	5	0	0
6	6	5	0	0
Total		49	1	3
Average		8.1	0.1	0.5

to the suture line. Table 4 represents animals killed up to 21 days. The average number of granulomas is the same as Table 3. No peritoneal adhesions were found. However, after the 10th day all animals showed adhesions to the suture line.

Table 5 represents animals treated with varying amounts of hydrocortisone. Beyond a dose of 1 mg. the results appear identical.

Microscopic Findings. — All controls showed granulomas and adhesions composed of a large number of macrophages, many of them multinucleated foreign-body giant cells, which contained or surrounded talcum particles. These were infiltrated with a varying number of lymphocytes and polymorphonuclear leucocytes and were poorly vascularized (Fig. 1). Small abscesses containing talcum particles were occasionally found within the granulomata. Reticulin stain revealed an intricate skeleton of reticulin fibrils which surrounded individual talcum particles or small collections of them (Fig. 2).

Animals Treated with Plasmin, with Plasminogen, or with Cortisone Subcutaneously: The histologic picture revealed by standard and reticulin stains was identical with that described in controls.

Animals Treated with Cortisone Intraperitoneally: In this group granulomata and adhesions were composed of the same elements as described in the controls; however, the number of macrophages, multinucleated giant cells, and amount of reticulin fibrils were considerably reduced. In many areas large groups of talcum particles were lying free. In such areas no reticulin was present (Fig. 3).

Animals Treated with Hydrocortisone, Intraperitoneally: This group showed the

Fig. 1.—Talcum granuloma in control animal. × 140. Hematoxylin-and-eosin stain.

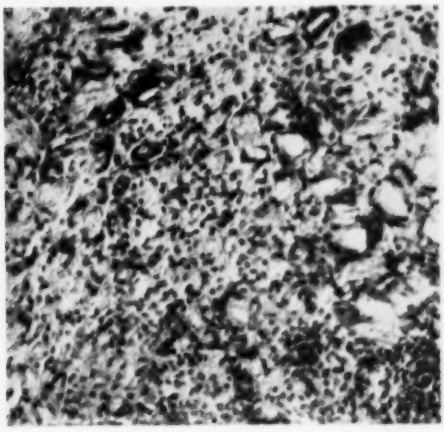
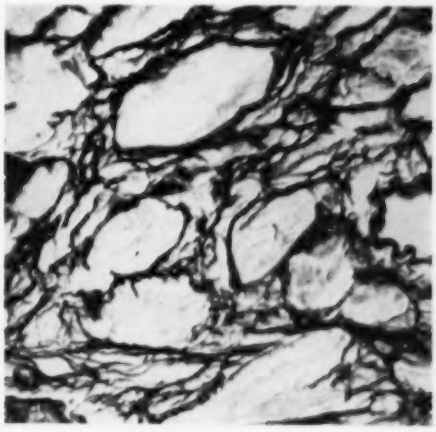


Fig. 2.—Reticulum network completely organizing talcum granuloma in control animal. × 400. Laidlaw's reticulum stain.



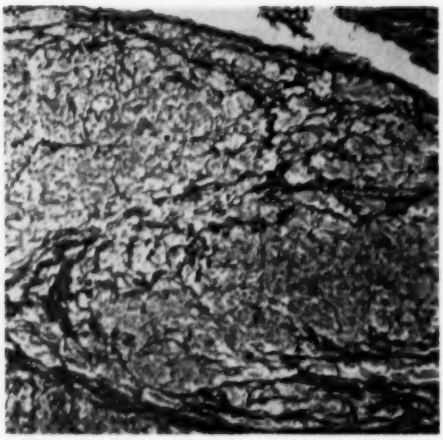


Fig. 3.—Intraperitoneal cortisone. Reticulin network has only partly organized the talcum mass. × 100. Laidlaw's reticulum stain.

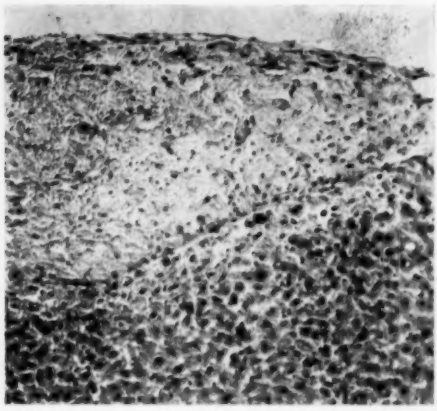


Fig. 4.—Intraperitoneal hydrocortisone. Solitary histiocytes within talcum mass. The latter has none of the characteristics of granulomata. × 100. Hematoxylin-and-eosin stain.

most marked histological difference from the controls. Sections showed dense masses of nonphagocytosed talcum particles mixed with lymphocytes, few histiocytes, and nuclear debris, all held together by a narrow peripheral ring of connective tissue (Fig. 4). Special stains revealed a well-developed reticulin network limited to the periphery of the mass and not penetrating into its body (Figs. 5 and 6).

Comment

Cortisone and hydrocortisone given intraperitoneally had a marked inhibitory effect on the formation of adhesions and granulomas in rats. The effect of hydrocortisone was clearly more marked than that of cortisone. It is significant that in 28 animals treated with more than 1 mg. of hydrocortisone per 100 gm. of body weight, up to 21 days, only a single animal developed adhesions (Tables 2, 3, 4, and 5). Cortisone given subcutaneously was without effect. The depressed granuloma formation in the plasmin-treated group could be accounted for by the SK-SD present in the solution.

Histologically these variously treated experimental animals can be divided into three groups: (1) animals treated either with plasmin, plasminogen, or cortisone subcu-

Fig. 5.—Intraperitoneal hydrocortisone. No reticulin fibers penetrating talcum mass. × 100. Laidlaw's reticulum stain.

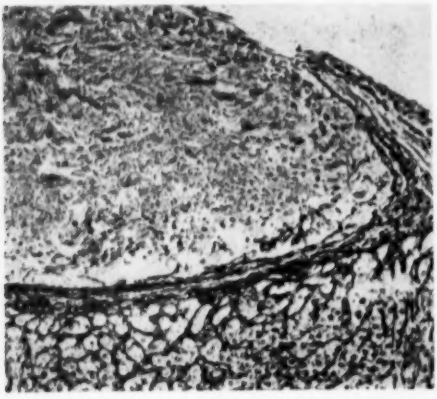
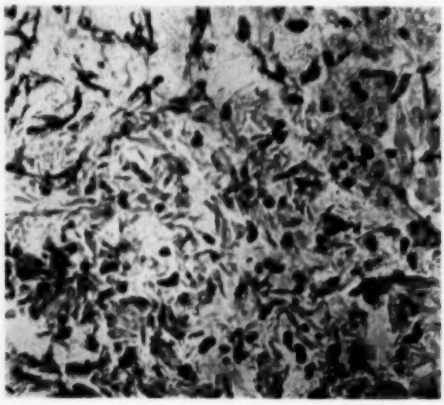


Fig. 6.—Same as Fig. 5. Compare with Fig. 2. × 300. Laidlaw's reticulum stain.



taneously; (2) cortisone-treated animals, intraperitoneally; (3) hydrocortisone-treated animals, intraperitoneally.

Group 1 showed a picture histologically identical to the control group. The cortisone-treated group showed a similar picture, but the number of giant cells and macrophages was significantly less. The hydrocortisone-treated group showed an entirely different histological picture with a complete absence of macrophages and foreign-body giant cells and failure of reticulin fibers to penetrate the foreign-body mass, which possibly account for their nonadherent quality. A similar effect on experimentally produced talcum arachnoiditis has been observed by one of us.[10]

In Table 3 and 4 the hydrocortisone-treated animals are charted against SK-SD-treated animals under identical conditions in a previously published experiment.[2] The data show that while a single injection of SK-SD prevented adhesion formation for a period of 8 days, the effect of a single injection of hydrocortisone exerted a similar effect up to 21 days. The number of granulomas in the SK-SD-treated group increased markedly after eight days, while in the hydrocortisone-treated group this increase is hardly significant. The adhesions to the suture line showed a similar but less striking difference. In the SK-SD-treated group almost every animal developed adhesions to the suture line, while in the hydrocortisone-treated group only half developed such adhesions. Histologically, the granulomas in the SK-SD-treated group showed no difference from the controls though they were clearly different in number.

No evidence of toxicity was observed in the hydrocortisone-treated group. However, two of the animals showed a dehiscence of the skin wound, and in three a wound infection occurred. None of the animals died.

Summary

A comparative study of the effect of fibrinolytic agents and corticosteroids on talc produced adhesions and granulomas in rats showed that cortisone and hydrocortisone given intraperitoneally were effective in preventing adhesion formation and reducing the number of granulomas. The effect of hydrocortisone was clearly superior to that of cortisone, and to that of streptokinase-streptodornase. Plasminogen and plasmin given intraperitoneally and cortisone given subcutaneously were without effect. The differences were demonstrable quantitatively and histologically.

P. O. Box 499.

REFERENCES

1. Wright, L. T.; Smiths, D. H.; Rothman, M.; Quash, E. T., and Metzger, W. I.: Prevention of Postoperative Adhesions in Rabbits with Streptococcal Metabolites, Proc. Soc. Exper. Biol. & Med. 75:602 (Nov.) 1950.

2. Luttwak, E. M.; Feldman, J. D., and Neuman, Z.: Effect of Streptokinase-Streptodornase on Peritoneal Talc Adhesions and Granulomas, A. M. A. Arch. Surg. 68:69 (Jan.) 1954.

3. Sherry, S.; Callaway, D. W., and Freiberg, R.: Prevention of Postoperative Adhesions in the Dog by Intravenous Injections of Plasminogen Activators, Proc. Soc. Exper. Biol. & Med. 90:1 (Oct.) 1955.

4. Hubay, C. A.; Weckesser, E. C., and Holden, W. D.: The Effect of Cortisone on the Prevention of Peritoneal Adhesions, Surg. Gynec. & Obst. 96:65 (Jan.) 1953.

5. Zachariae, L.: Hydrocortisone Acetate Applied Intraperitoneally: Inhibitory Effect on Adhesions Produced by Talc, Acta endocrinol. 16:149, 1954.

6. De Sanctis, A. L.; Schatten, E. W., and Weckesser, E. C.: Effect of Hydrocortisone in the Prevention of Intraperitoneal Adhesions, A. M. A. Arch. Surg. 71:523 (Oct.) 1955.

7. Cliffton, E. E., and Cannamela, D. A.: Proteolytic and Fibrinolytic Activity of Serum; Activation by Streptokinase and Staphylokinase Indicating Dissimilarity of Enzymes, Blood 8:554 (June) 1953.

8. Cliffton, E. E., and Cannamela, D. A.: Fibrinolytic and Proteolytic Activity of a Human "Plasminogen," Prepared from Fraction III of Human Plasma, J. Appl. Physiol. 6:42 (July) 1953.

9. Sherry, S.: The Fibrinolytic Activity of Streptokinase Activated Human Plasmin, J. Clin. Invest. 33:1054 (July) 1954.

10. Behar, A. J., and Feldman, S.: Pathogenesis of Adhesive Arachnoiditis, J. Neuropath. & Exper. Neurol., to be published.

Myelographic Demonstration of Brachial Plexus Root Avulsion

MAJOR R. A. MENDELSOHN, San Antonio, Texas; I. H. WEINER, M.D., Baltimore, and MAJOR J. M. KEEGAN, San Antonio, Texas

Introduction

Stretch injuries to the brachial plexus with permanent residual disability are relatively infrequent. However, each case usually results in severe functional impairment for the patient and represents a difficult problem in management for the physician. Stretch injuries of the brachial plexus are classically divided into three types: Erb-Duchenne upper type, Klumpke's lower type, and the combined type. The Erb-Duchenne type, involving the fibers derived from C-5 and C-6, usually occurs when the head is forcibly separated from the shoulder. The Klumpke type, involving C-8 and T-1 fibers, usually results from forcible hyperabduction of the upper extremity at the shoulder. The combined type may range from complete plexus involvement to the simple addition of C-7 to either of the first two types.

The term "avulsion of the brachial plexus" applies to actual separation of the nerve rootlets from the spinal cord. A presumptive diagnosis of avulsion of the brachial plexus can be made clinically on the basis of involvement of structures which are innervated by nerves arising at the root level. For example, in the upper-type lesion, involvement of the muscles supplied by the long thoracic nerve (serratus anterior) and dorsal scapular nerve (rhomboids), and in the lower-type lesion, a Horner's syndrome, imply avulsion of the corresponding nerve roots. The diagnosis is presumptive because the nature of the lesion is not defined. Frequently, however, clinical examination is not conclusive as to the exact site or nature of the lesion within the brachial plexus. Since both the location and the nature of the lesion are important in determining management, additional diagnostic aids may assume a critical role in the evaluation of these factors.

In 1947 Murphey, Hartung, and Kirklin [3] first reported myelographic changes which they felt were indicative of root avulsion. Their case was clinically an avulsion of C-7, C-8, and T-1. Because of persistent forearm and hand pain which presented a difficult diagnostic problem, a concomitant disk protrusion was considered and a cervical myelogram done. No evidence of disk herniation was seen. However, they noted migration of the radiopaque oil through the region of the intervertebral foramina at C-7, C-8, and T-1, to outline pouches or diverticula extending extraspinally into the cervical soft tissues. To these pouches they applied the term "traumatic meningocele," although they were not certain that the outpouchings were lined by meninges. The striking myelographic findings, coupled with the clear-cut neurologic involvement, despite lack of surgical verification, led them to the conclusion that the myelographic picture represented nerve root avulsion.

In 1949 Murphey and Kirklin [4] presented seven cases before the Clinical Congress of the American College of Surgeons, verifying the diagnosis in three by extraspinal operation. In 1950 Whiteleather and Clayton [8] reported three cases from the private

Submitted for publication Feb. 6, 1957.

From the Neurosurgery and Radiology Services of the U. S. Air Force Hospital, Lackland Air Force Base.

Presented at the Fourth Annual Scientific Meeting, Houston Neurological Society, Houston, Texas, March 17, 1956.

services of Murphey and Semmes with the typical myelographic findings, one of which was verified by extraspinal operation. In 1953 Jaeger and Whiteley[2] presented six cases of brachial plexus avulsion. Myelograms were done in three of these. In one of the three the myelographic diagnosis of avulsion was made, without surgical verification. The other two myelograms revealed no abnormality, and intradural exploration confirmed avulsion. It must be noted that the two negative myelograms were done by the cisternal route, and the amount of iophendylate (Pantopaque) employed was not stated. Ehni,[1] in 1953, in a paper on peripheral nerve and plexus trauma, presented a myelogram of a patient of R. C. L. Robertson's with the typical traumatic meningoceles due to brachial plexus root avulsion.

White and Hanelin,[7] in 1954, reported three additional cases of myelographic abnormalities associated with clincal evidence of root avulsion. One case was explored intradurally, and the operative finding of root avulsion confirmed the myelographic diagnosis. In addition, the pouches were noted to be lined with meninges, thus confirming Murphey's original term of "traumatic meningocele."

Tarlov in 1954,[6] reported two cases of avulsion each of which demonstrated the meningocele defects at myelography, and each was confirmed at laminectomy. He also had one case in which the clinical diagnosis was an avulsion but which, at

Fig. 1. (Case 1).—Cervical myelogram of a patient with an upper type of brachial plexus lesion. The typical traumatic meningoceles are demonstrated on the fifth and sixth roots on the left. A presumptive clinical diagnosis of root avulsion could not be made in this case.

myelography, revealed replacement of the axillary pouches by concave defects. At operation, he found avulsion and scar tissue obliterating the normal arachnoidal and dural apertures at the level of the avulsed roots.

In 1955 Rayle et al.[5] presented nine cases having the myelographic picture of root avulsion. In seven of these cases this radio-

Clinical Data on Eleven Cases of Brachial Plexus

Case No.	Age, Yr.	Interval Between Injury and Myelography	Type (Segmental Involvement)	Myelographic Involvement	Clinical Evidence of Avulsion
1	20	6 mo.	Upper (C-5 & C-6)	C-5 & C-6	None
2	24	5 yr.	Upper (C-5 & C-6)	C-6	None
3	21	3 wk.	Lower (C-8 & T-1)	T-1	Horner's syndrome
4	27	6 mo.	Combined (C-5, C-6, C-7, C-8, & T-1)	C-6 & C-7	Paralysis of rhomboids and serratus anterior; no Horner's syndrome
5	22	7 mo.	Combined (C-5, C-6, & C-7)	C-6 & C-7	None
6	38	2½ yr.	Combined (C-7, C-8, & T-1)	C-7, C-8, & T-1	None
7	20	3 mo.	Combined (C-7, C-8, & T-1)	C-7, C-8, & T-1	Horner's syndrome
8	23	1½ yr.	Combined (C-7, C-8, & T-1)	None	None
9	28	5 mo.	Combined (C-7, C-8, & T-1)	None	None
10	18	5 mo.	Combined (C-7, C-8, & T-1)	None	None
11	21	3 mo.	Combined (C-6 & C-7)	None	None

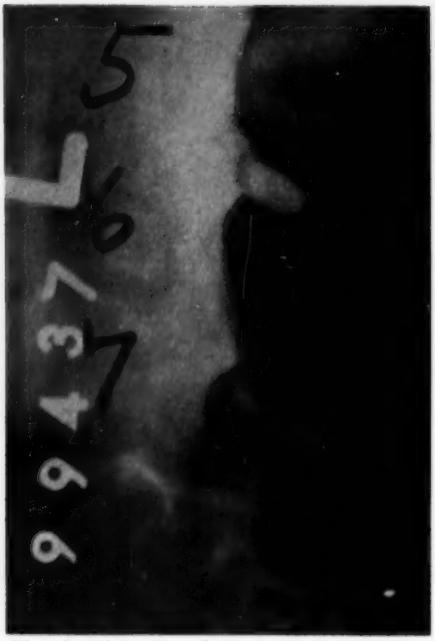
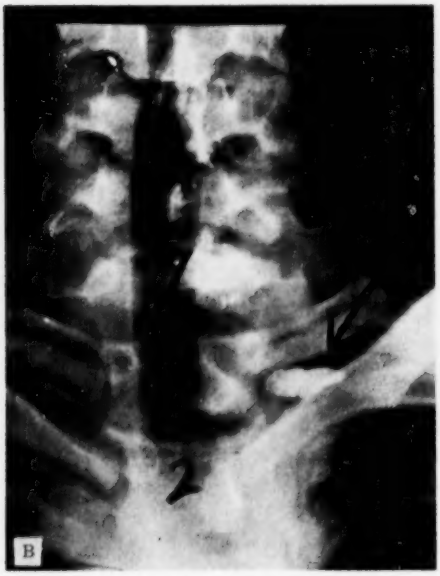


Fig. 2 (Case 2).—Cervical myelogram of a patient with an upper-type brachial lesion. Elongation of the C-6 axillary pouch on the right is demonstrated. A presumptive clinical diagnosis of root avulsion could not be made.

Fig. 3 (Case 3).—Cervical myelogram of a patient with a lower type of brachial plexus lesion. *A*, migration of the opaque medium in the region of the T-1 nerve root is demonstrated.



B, the opaque medium is seen to remain in the pouch after the removal of the iophendylate (Pantopaque).

A presumptive clinical diagnosis of avulsion injury was made on the basis of a Horner's syndrome.

graphic diagnosis correlated with the clinical impression of avulsion. In one of the remaining two cases the defect was due to laminectomy for cervical disk herniation, the dura having been left open. The other was an incidental finding, etiology not known, but thought possibly to be congenital. In neither of the latter two cases was there anything to suggest a root avulsion.

Presentation of Cases

During the last year, we have seen 11 cases of stretch injury to the brachial plexus on the neurosurgical service of the U. S. Air Force Hospital, Lackland Air Force Base (Table). Myelography was done in all cases, no effort being made to select candidates for myelography on a clinical diagnosis of root avulsion. In all cases myelography was performed via the lumbar route, using 9 cc. of iophendylate. The opaque medium was allowed to pool in the cervical area for at least 10 minutes because of the previously noted delay in filling of the pouches in certain cases. We have found that slight rotation of the head with the suspected side down sometimes facilitates migration of the medium into the pouches. It is of interest that 7 out of these 11 cases did show evidence of

Fig. 4 (Case 4).—Cervical myelogram of a patient with a total brachial plexus lesion. Elongation of the axillary pouch of C-6 on the left, less marked elongation at C-5, and a concave cut-off of the axillary pouch at C-7 is demonstrated. A presumptive clinical diagnosis of avulsion injury was made because of paralysis of the rhomboids and serratus anterior and the presence of a Horner's syndrome.

injury at the root level, a surprisingly high incidence in this small series. Two of the cases with normal myelograms had plexus explorations, and in both the lesion was demonstrated to be extraspinal. In the other two cases with normal myelograms there was rapid recovery of function, so that it was concluded that root avulsion had not occurred (Figs. 1 to 7).

Comment

Two types of myelographic changes have been described in previous articles. The more striking and commoner demonstration is that of diverticula extending from the subarachnoid space through the intervertebral foramen into the cervical soft tissues. This is due to tearing of the dural and arachnoid cuff, with leakage of spinal fluid through the tear. Less commonly, filling defects at the level of, and replacing, the normal root pouches have been described. These are apparently due to localized scarring without meningocele formation. In our series of cases deformities of both types were observed. Several of our studies disclosed only slight prolongation of the axillary pouch, which was also interpreted as evidence of avulsion.

The significance of these myelographic changes is not wholly established. That they indicate severe injury at the prognostically unfavorable root level is clear. Nevertheless, the correlation of clinical findings, myelographic abnormalities, and operative findings (in the few reported cases in which intradural exploration was done) is not perfect. Usually the clinical picture indicates a more widespread lesion than is myelographically demonstrable. This is probably explainable on the basis of traction injury, without discontinuity, at roots above or below those avulsed. Occasionally, anatomic variation in the structure of the brachial plexus contributes to lack of exact correlation. Also, there seems little doubt that avulsion of a given root may be un-

Fig. 5 (Case 5).—Cervical myelogram of a patient with a combined type of brachial plexus lesion (segmental involvement of C-5, C-6, and C-7). Large traumatic meningoceles are demonstrated in the region of the C-6 and C-7 roots on the left. A presumptive clinical diagnosis could not be made in this case.

Fig. 6 (Case 6).—Cervical myelogram of a patient with a combined type (segmental involvement of C-7, C-8, and T-1) of brachial plexus lesion. Traumatic meningoceles are demonstrated at C-8 and T-1 and a less severe defect at C-7 on the right. A presumptive clinical diagnosis of avulsion injury could not be made in this case.

accompanied by myelographic changes at the corresponding level.

Despite these occasional discrepancies, we feel that the informaton obtained by myelography is valuable in the evaluation of plexus injuries. In four of the seven cases with myelographic evidence of avulsion, a presumptive diagnosis of nerve root avulsion could not have been made. In none of the four cases with normal myelograms was there clinical evidence to suggest avulsion of nerve roots.

If the myelogram is abnormal, and if it correlates reasonably well with the clinical findings, we believe that operation with intent to repair neural damage is not indicated. We delay several months for the frequent initial period of improvement of disability due to associated simple stretch injury. Patients are then reevaluated and reconstructive surgery is considered. Cases of poor correlation usually are those of widespread and severe neurologic deficit with minimal myelographic findings. Exploration is justified in these cases to establish an accurate prognosis and to allow for early reconstructive surgery or amputation if indicated. In cases in which the myelogram is normal, exploration of the plexus itself may be considered.

Summary

Eleven cases of stretch injury of the brachial plexus were seen on the neurosurgical service of the U. S. Air Force Hospital, Lackland Air Force Base, in the past year. Myelography was done in all cases, no attempt being made to select patients on the basis of a clinical diagnosis of nerve root avulsion.

In 7 out of 11 of these cases myelographic abnormalities were found and were interpreted as nerve root avulsion. Although this series is a small one, it suggests the

Fig. 7 (Case 7).—Cervical myelogram of a patient with a combined type of brachial plexus lesion (segmental involvement of C-7, C-8, and T-1). A large pouch is seen at T-1, with slighter defects at C-7 and C-8 on the right. A presumptive clinical diagnosis of root avulsion was made on the basis of a Horner's syndrome.

possibility that nerve root avulsion in stretch injuries of the brachial plexus is commoner than is generally thought.

In four of the seven cases with myelographic findings of nerve root avulsion a clinical diagnosis of nerve root avulsion could not be made on the basis of involvement of structures innervated at the root level.

Myelography is a valuable adjunct in the management of stretch injuries of the brachial plexus. It provides additional data for more accurate prognostication. If myelography demonstrates nerve root avulsion, exploration of the brachial plexus is not indicated, and early reconstructive surgery may be done.

3700th U. S. A. F. Hospital, P. O. Box 1559, Lackland Air Force Base (Major Mendelsohn and Major Keegan).

Department of Neurosurgery, University Hospital, Baltimore (Dr. Weiner).

REFERENCES

1. Ehni, G.: Injuries of Peripheral Nerves and Plexuses: Current Methods of Treatment, S. Clin. North America 33:593-606, 1953.

2. Jaeger, R., and Whiteley, W. H.; Avulsion of the Brachial Plexus, J. A. M. A. 153:633-635, 1953.

3. Murphey, F.; Hartung, W., and Kirklin, J. W.: Myelographic Demonstration of Avulsing Injury of the Brachial Plexus, Am. J. Roentgenol. 58:102-105, 1947.

4. Murphey, F., and Kirklin, J. W.: Myelographic Demonstration of Avulsing Injuries of the Brachial Plexus, read before the Clinical Congress of the American College of Surgeons, Chicago, 1949; cited by Jaeger and Whiteley.[2]

5. Rayle, A. A.; Gay, B. B., Jr., and Meadors, J. L.: The Myelogram in Avulsion of the Brachial Plexus, Radiology 65:65-72, 1955.

6. Tarlov, I. M.: Myelography to Help Localize Traction Lesions of the Brachial Plexus, Am. J. Surg. 88:266-271, 1954.

7. White, J. C., and Hanelin, J.: Myelographic Sign of Brachial Plexus Avulsion, J. Bone & Joint Surg. 36-A:113-118, 1954.

8. Whiteleather, J. E., and Clayton, R. S.: Traumatic Avulsion of Nerve Roots, M. Radiog. & Photog. 26:27-29, 1950.

Cephalic Sympathetic Nerves

Components and Surgical Implications

ALBERT KUNTZ,† Ph.D., M.D.; HENRY H. HOFFMAN, Ph.D., and LEONARD M. NAPOLITANO, Ph.D.,
St. Louis

The cephalic sympathetic nerves have been adequately described anatomically. They are derived chiefly through the internal and external carotid and the vertebral nerves and plexuses. According to current concepts, the preganglionic fibers concerned are included in the thoracolumbar outflow and make synaptic connections predominantly in the cervical sympathetic trunk. Ganglia occur frequently in the internal carotid plexus.[2,5,11] A single small ganglion in the external carotid plexus near the origin of the facial artery has also been reported.[10] It has been assumed quite generally that preganglionic fibers reach these ganglia through rami that extend cephalad from the superior cervical sympathetic trunk ganglion and through the plexus on the common carotid artery.

Adequate data relative to the frequency, size, and distribution of ganglia in the internal carotid nerve and plexus are wanting. According to Mitchell,[12] macroscopic ganglia occur only infrequently. He has observed microscopic ganglia at various levels along the internal carotid artery. He[11] also corroborated in animals, but not in man, the findings of Ribes[14] in man that in some instances a small ganglion occurs adjacent to the anterior communicating artery. In view of the occurrence of ganglia in the internal carotid plexus and, at least in some instances, of an unpaired ganglion adjacent to the anterior communicating artery, Mitchell proposed that the internal carotid plexus be regarded as the cephalic portion of the sympathetic trunk, which ends rostrally in an unpaired ganglion comparable to the ganglion impar, in which both sympathetic trunks end caudally.

Both the internal and the external carotid plexuses are commonly regarded as predominantly sympathetic, but they are known to include some afferent fibers.[6] The assumption that the internal carotid nerve also includes preganglionic fibers is supported by anatomical data.[5] Complete removal of the sympathetic fibers that enter the cranial cavity along the carotid and the vertebral arteries, according to Chorobski and Penfield,[2] does not appreciably reduce the number of intact intracranial perivascular nerve fibers. They also found that the cerebral blood vessels are not completely denervated by section of both the sympathetic and the parasympathetic nerves. They postulated synaptic relays in sympathetic pathways rostral to the superior cervical sympathetic trunk ganglion.

The carotid nerves are made up predominantly of unmyelinated fibers, but they include myelinated ones of various sizes. The sources of the fibers in the several categories are not fully known. The present investigation has been undertaken to obtain additional data relative to the fibers of the cephalic sympathetic nerves and the frequency and distribution of ganglia in them.

Materials and Methods

Detailed dissection of the internal carotid artery with the nerves associated with it has been carried out bilaterally in a series of human cadavers and

Submitted for publication Jan. 18, 1957.

Supported by U. S. P. H. S. Grant-666.

Fellow, Life Insurance Medical Research Fund (Dr. Napolitano).

From the Department of Anatomy, St. Louis University School of Medicine.

†Dr. Kuntz died Jan. 19, 1957.

a series of cats. Every artery with the nerves associated with it was divided into pieces of which longitudinal sections could be mounted on 3×1.5 in. slides. The longitudinal sections, cut at a thickness of 16μ to 20μ, were mounted serially and stained with hematoxylin and eosin. The sections were examined for ganglion cells, and the ganglia found were localized as accurately as possible on diagrams of the arteries. Counts of the ganglion cells in every ganglion were recorded. Serial longitudinal sections of the external carotid artery and its major branches with the adjacent nerves were also examined for ganglion cells.

Transverse sections of the roots of the internal and external carotid nerves in man, stained with osmic acid or Sudan black B, were examined for myelinated fibers. The corresponding rami in the cat were fixed and stained in a 0.5% osmic acid solution. Transverse sections of these rami were also examined for myelinated fibers.

In one series of cats the vagosympathetic trunk was severed unilaterally 3 to 5 cm. caudal to the superior cervical and nodose ganglia, and any other rami connected with the superior cervical ganglion except at its rostral pole were interrupted. In some animals the connections between the superior cervical sympathetic and nodose ganglia were interrupted. In others these connections remained intact. After ample time for the degeneration of the interrupted fibers, the rami extending from the superior cervical sympathetic ganglion rostrad along the internal carotid artery were removed bilaterally and prepared according to the osmic acid technique. Transverse sections of the nerves on both sides were examined for myelinated fibers.

Anatomical Data

Man

Internal Carotid Nerve and Plexus.—The internal carotid nerve arises from the rostral pole of the superior cervical sympathetic trunk ganglion in a variable number of fiber bundles, which are usually enclosed in a common connective tissue sheath (Fig. 2*A*). It extends rostrad along the dorsal aspect of the internal carotid artery and, with the artery, enters the carotid canal. Within the carotid canal it gives off branches that join the plexus investing the internal carotid artery. This neural complex extends throughout the entire length of the internal carotid artery and is continuous with subsidiary plexuses on its branches. The extracranial portion of the internal carotid plexus is joined by two or more slender rami that arise from the superior cervical sympathetic ganglion apart from the internal carotid nerve. On this part of the artery the periarterial plexus is relatively meager except in the zone of distribution of the carotid sinus nerve, where afferent fibers predominate.

Ganglia.—The observation of various investigators that a ganglion of macroscopic size frequently occurs in the internal carotid nerve before it enters the carotid canal has been corroborated. The approximate locations of such ganglia are indicated diagrammatically by the lower ganglia in *4*, *5*, and *6* (Fig. 1). Microscopic examination of serial longitudinal sections of the internal carotid artery and the nerves adjacent to it has also revealed numerous ganglia in the internal carotid nerve and plexus at more rostral levels. Some are located within the cranial cavity, but a ganglion located in relation to the anterior communicating artery, as described by Ribes,[14] was not observed in our preparations.

The ganglia in single internal carotid nerves and plexuses vary in number and size within a wide range. In our examination of serial longitudinal sections of six pairs of internal carotid arteries and the adjacent nerves, the number of ganglia observed in single internal carotid nerves and plexuses varied from 2 to 12. Three to six ganglia occurred most commonly. The ganglia also vary greatly in size and in the numbers of their constituent ganglion cells. The lowest number of ganglion cells counted in a single ganglion is 8, the highest number is in excess of 27,000. The ganglion cells observed are comparable to those in the sympathetic trunk ganglia. In some of the ganglia they are completely aggregated; in others they are somewhat diffusely scattered. The approximate locations of the ganglia observed along the internal carotid arteries in six human bodies are illustrated diagrammatically in Figure 1. The adjacent numer-

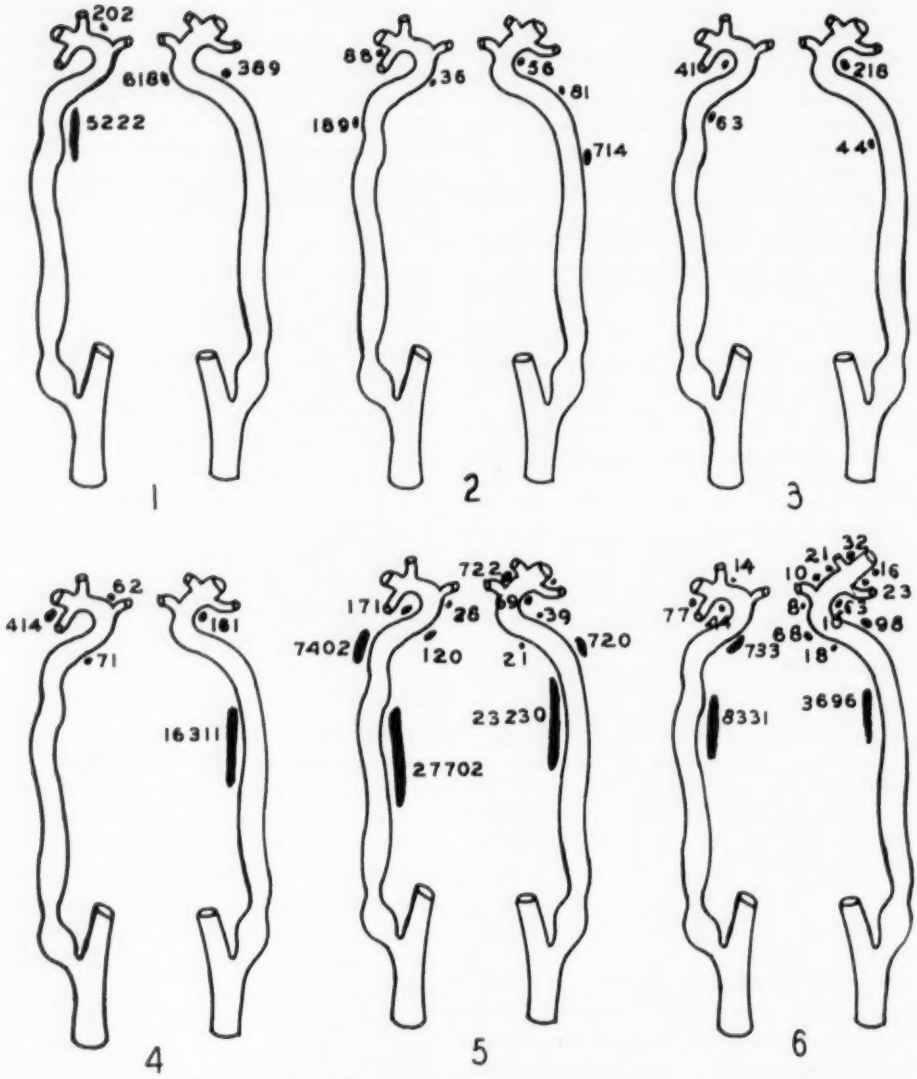


Fig. 1.—Diagrams illustrating the approximate locations of ganglia observed in the internal carotid nerves and plexuses in six human bodies. The ganglia are represented in solid black. The adjacent numerals indicate the number of ganglion cells counted in every ganglion.

als indicate the numbers of ganglion cells counted in every ganglion.

Fiber Components.—As observed in transverse sections of the internal carotid nerve taken 1 to 2 cm. rostral to its origin from the superior cervical sympathetic ganglion, and stained with osmic acid or Sudan black B, the internal carotid nerve appears to be made up predominantly of unmyelinated fibers, but it includes myelinated ones in large numbers. Most of the myelinated fibers are less than 4μ in diameter; i. e., they fall within the caliber range of pre- and postganglionic fibers. Myelinated fibers of somewhat larger caliber occur in small numbers.

External Carotid Plexus.—The neural plexus that invests the external carotid artery is continuous with subsidiary plexuses on the branches of this artery. It is also continuous with the common carotid plexus, but it is derived chiefly through rami that arise from the ventral surface of the superior cervical sympathetic trunk ganglion. These rami are frequently conjoined with rami that join the extracranial portion of the internal carotid plexus. According to Lazorthes,[10] the external carotid plexus includes a small ganglion just caudal to the origin of the facial artery. We cannot corroborate this finding in man, but groups of ganglion cells have been observed in the external carotid plexus and its subsidiaries. The subsidiary plexuses are connected with adjacent cranial nerves through slender rami.

The rami extending from the ventral aspect of the superior cervical sympathetic trunk ganglion are made up predominantly of unmyelinated fibers, but they include some myelinated ones that fall within the caliber range of most of the myelinated components of the internal carotid nerve. The percentage of myelinated fibers in these rami is markedly lower than that of the myelinated fibers in the internal carotid nerve.

Both the external carotid plexus and the nerves investing the branches of the external carotid artery include some myelinated fibers of larger caliber than any of those derived from the superior cervical sympathetic trunk ganglion. They probably represent afferent components chiefly of the vagus nerve.

Internal Jugular Nerve.—The internal jugular nerve arises from the rostral portion of the superior cervical sympathetic ganglion or from the internal carotid nerve. Most of its fibers join the glossopharyngeal nerve. Some enter the cranial cavity to be distributed to the jugular bulb and the meninges in the posterior fossa.

The Cat

Internal Carotid Nerve.—In the cat, as in man, the internal carotid nerve arises from the rostral pole of the superior cervical sympathetic trunk ganglion. It consists of a variable number of nerve fiber bundles (Fig. 2*B*), most of which enter the cranial cavity through the foramen ovale. Its distribution appears to be comparable to that of the internal carotid nerve in man. It also includes small ganglia. An inconstant ganglion has been observed repeatedly in the course of the nerve within a few centimeters of its origin. Groups of ganglion cells have also been observed in the intracranial portion of the nerve.

The percentage of myelinated fibers in the internal carotid nerve is markedly higher in the cat than in man. Most of the myelinated fibers do not exceed 3.5μ, and many are less than 3μ in diameter. Fibers over 4μ in diameter occur in relatively small numbers. Section of the sympathetic trunk caudal to the superior cervical ganglion results in appreciable diminution in the number of myelinated fibers in the internal carotid nerve. The density of the myelinated fibers in a typical component bundle of the internal carotid nerve is illustrated in Figure 2*C*. The myelinated fibers that remained intact in a corresponding bundle on the opposite side following degeneration of the fibers interrupted by section of the sympathetic trunk are illustrated in Figure 2*D*. A limited number of counts of the myelinated fibers in comparable unit areas of transverse sections of both internal carotid nerves, stained with osmic acid, following degeneration of the fibers interrupted by section of the sympathetic trunk on one side, showed 15% to 30% fewer myelinated fibers in the nerve on the side on which the sympathetic trunk was severed than on the control side. The percentage of reduction of myelinated fibers in the internal carotid nerve following section of the sympathetic trunk appears to vary with the abundance of ganglion cells in the nerve and the internal carotid plexus. The myelinated fibers in the internal carotid nerve, consequently, appear to be predominantly postganglionic, but those that undergo de-

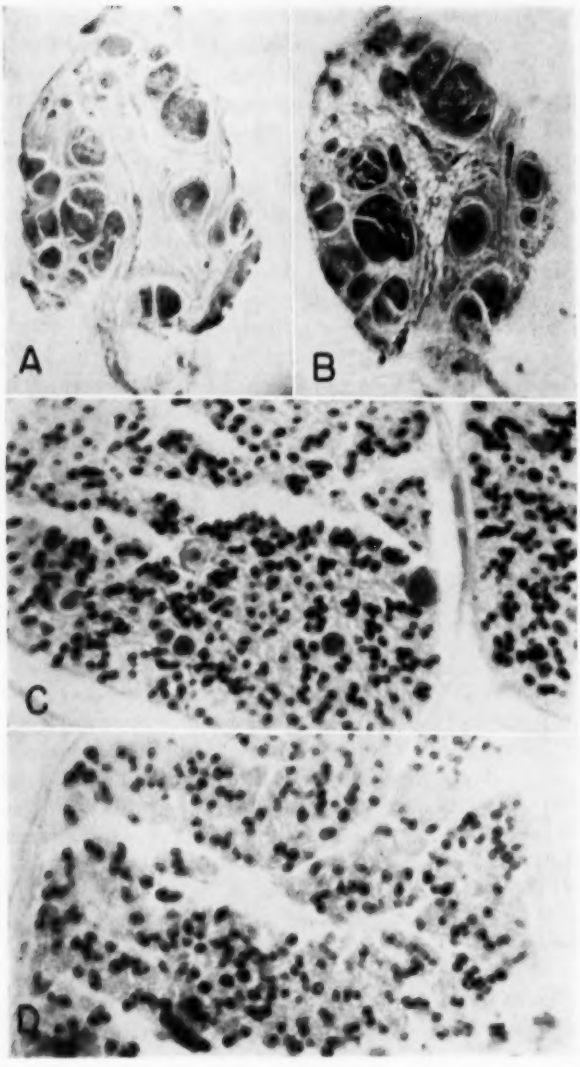


Fig. 2.—*A*, photomicrograph (low power) of a transverse section of a human internal carotid nerve approximately 2 cm. from the rostral pole of the superior cervical sympathetic trunk ganglion.

B, photomicrograph of a transverse section of the proximal portion of an internal carotid nerve of a cat (magnification somewhat higher than that of *A*).

C, photomicrograph from an osmic-acid preparation of a normal internal carotid nerve of a cat showing density of myelinated fibers.

D, photomicrograph from an osmic-acid preparation of the contralateral internal carotid nerve of the same cat in which the fibers interrupted by section of the sympathetic trunk had undergone degeneration, showing reduced density of myelinated fibers.

generation following section of the sympathetic trunk caudal to the superior cervical ganglion undoubtedly are preganglionic. Interruption of the rami connected with the superior cervical sympathetic ganglion except those that connect it with the nodose ganglion and those that extend rostrad from its rostral pole, in addition to section of the sympathetic trunk, resulted in but little more marked diminution in the number of myelinated fibers in the internal carotid nerve than section of the sympathetic trunk alone. The occurrence in the internal carotid nerve of some fibers of large caliber than either pre- or postganglionic fibers, both before and after degeneration of the fibers interrupted by the operative procedure described above, supports the assumption that the internal carotid nerve includes some fibers that do not traverse the superior cervical sympathetic trunk ganglion or arise in it. Interruption of the connections be-

tween the nodose and the superior cervical sympathetic ganglion, in addition to the above procedures, resulted in still further reduction in the number of myelinated fibers over 3.5μ in diameter, but not in complete elimination of fibers in this category. Some of the larger myelinated fibers in the internal carotid nerve, consequently, appear to be of vagal origin.

External Carotid Nerve.—Two or more slender rami extend from the ventral surface of the superior cervical sympathetic trunk ganglion to the external carotid artery and join the neural plexuses on this artery and its branches. These plexuses also include small ganglia. Ganglia have been observed particularly in the plexuses on the lingual, the occipital, and the inferior dental arteries. Longitudinal serial sections of these arteries and the adjacent nerves in a single cat revealed two small ganglia near the origin of the lingual artery, in one of which 62, and in the other 18, ganglion cells were counted and one containing 31 ganglion cells in the plexus investing the inferior dental artery.

The rami that extend from the superior cervical ganglion to the external carotid artery and its branches are made up predominantly of unmyelinated fibers, but include some myelinated ones. Most of the myelinated fibers fall within the caliber range of those in the internal carotid nerve. These rami are predominantly postganglionic, but they probably include preganglionic fibers to ganglia located in the plexuses on the external carotid artery and its branches.

The neural plexuses on the external carotid artery and its branches, as observed in transverse sections stained with osmic acid, are made up predominantly of unmyelinated fibers, but include some myelinated ones, some of which are larger than any of the myelinated fibers derived from the superior cervical sympathetic trunk ganglion. They probably represent afferent cranial nerve components.

Comment

The internal carotid nerves represent the major portion of the extension of the sympathetic nerves into the head. The data obtained in the present investigation confirm the occurrence of ganglia in these nerves, but they add nothing new in support of the assumption that the internal carotid nerve and plexus represent the cephalic portion of the sympathetic trunk. With respect to the presence of ganglia in it, the internal carotid nerve does not differ significantly from other nerves that arise from the sympathetic trunk, e. g., the splanchnic nerves, which include numerous ganglia.[7,8,15] Like the splanchnic, the internal carotid nerves, as has been suggested by Chorobski and Penfield,[2] include abundant synaptic relays. The observation of Chorobski and Penfield[2] that the number of intact intracranial perivascular nerve fibers is not appreciably reduced following interruption of the sympathetic fibers that enter the cranial cavity along the carotid and vertebral arteries can be explained most satisfactorily on the assumption that the fibers that remain intact are predominantly the axons of sympathetic ganglion cells located rostral to the superior cervical sympathetic trunk ganglion.

Most of the fibers in the roots of the internal carotid nerve extend directly from the rostral pole of the superior cervical sympathetic trunk ganglion, but it includes some fibers that neither arise in this ganglion nor traverse it. The neural plexuses that invest the internal and external carotid arteries are continuous with the plexus that invests the common carotid artery. The latter plexus is relatively meager, but it includes both afferent and pre- and postganglionic fibers that arise in the rostral thoracic and caudal cervical segments. As observed by Mizeres[13] in the dog, it is made up in part of fibers that extend caudad from the superior cervical sympathetic ganglion. The frequency with which sympathetic fibers that traverse the common carotid plexus extend cephalad along the internal

carotid artery is unknown. Experimental data reported by Bullon [1] support the assumption that in the cat some sympathetic pathways to the nictitating membrane are independent of the superior cervical sympathetic ganglion. The occurrence in the internal and external carotid nerves and plexuses of afferent fibers of spinal and vagus origin has been demonstrated anatomically in the cat.[6] The occurrence in human internal and external carotid nerves of myelinated fibers larger than pre- and postganglionic ones supports the assumption that these nerves also include afferent fibers of spinal and vagus origin in man. Those of spinal origin do not traverse the superior cervical sympathetic ganglion. The assumption that afferent fibers of spinal and vagus origin are associated with the cephalic sympathetic nerves in man is also supported by physiological [4] and clinical [3,9,16] data. Sympathetic and afferent fibers extend from the vertebral plexuses rostrad along the basilar artery. They contribute in a limited measure to intracranial innervation. Connections between the superior cervical sympathetic ganglion and the vertebral plexus have been described, but it appears improbable that fibers derived from the vertebral plexus join the internal carotid nerve. The possibility that some fibers may join the internal carotid nerve through rami from rostal cervical nerves has been suggested.[11]

In both man and the cat the roots of the internal and external carotid nerves include myelinated fibers in relatively large numbers. As observed in the cat, varying percentages of the myelinated fibers in the internal carotid nerve underwent degeneration following section of the sympathetic trunk caudal to the superior cervical sympathetic ganglion. Since the sympathetic trunk probably includes no afferent fibers in the rostral cervical segments, the myelinated fibers in the roots of the internal carotid nerve that undergo degeneration following sympathetic trunk section must be regarded as preganglionic. Excepting a limited number derived from sources other than the superior cervical ganglion, the myelinated fibers that remain intact, like the unmyelinated ones, must be regarded as postganglionic. Some myelinated fibers in the external carotid nerve probably are also preganglionic. The preganglionic fibers in question undoubtedly make synaptic connections in the ganglia located in relation to the internal and external carotid nerves. These ganglia, therefore, must be regarded as sympathetic.

In view of all the data available, it is evident that extirpation of the superior cervical sympathetic trunk ganglion alone interrupts most of the cephalic sympathetic conduction pathways, but not all of them, since some preganglionic fibers that do not traverse the superior cervical ganglion may reach ganglia located in relation to the internal and external carotid nerves. Elimination of all sympathetic preganglionic fibers to these ganglia and complete sympathetic denervation of the head, as has been suggested,[5] probably can be accomplished by extirpation of the lower cervical and the upper two or three thoracic segments of the sympathetic trunk, since this procedure would interrupt all sympathetic preganglionic fibers known to extend cephalad.

Summary

The internal and external carotid nerves and plexuses represent the major portion of the extension of the sympathetic nerves into the head. They include ganglia in varying numbers and of varying sizes. The efferent fibers of both the internal and the external carotid nerve are derived chiefly from the superior cervical sympathetic trunk ganglion, but the internal carotid nerve includes some efferent fibers that neither arise in this ganglion nor traverse it. Both the internal and the external carotid nerve and plexus also include afferent nerve fibers.

In the cat, section of the sympathetic trunk caudal to the superior cervical ganglion results in degeneration of a varying percentage of the myelinated fibers in the internal carotid nerve. Those that undergo degeneration are regarded as pre-

ganglionic; those that remain intact are regarded as postganglionic. Interruption of the connections between the superior cervical sympathetic and the nodose ganglion in addition to section of the sympathetic trunk, results in degeneration of a somewhat larger percentage of the myelinated fibers in the internal carotid nerve than section of only the sympathetic trunk. The assumption that some vagus nerve fibers, probably afferent, traverse the internal carotid nerve, therefore, is supported.

Extirpation of the superior cervical sympathetic trunk ganglion results in interruption of most of the cephalic sympathetic conduction pathways, but not all of them. Complete sympathetic denervation of the head probably can be achieved by extirpation of the caudal cervical and the rostral two or three thoracic sympathetic trunk segments.

St. Louis University School of Medicine, 1402 S. Grand Blvd. (4).

REFERENCES

1. Bullon, A.: Experimental Studies in the Innervation of the Blood Vessels, Acta neuroveg. 13:329-330, 1956.

2. Chorobski, J., and Penfield, W.: Cerebral Vasodilator Nerves and Their Pathway from the Medulla Oblongata, Arch. Neurol. & Psychiat. 28:1257-1289, 1932.

3. Fay, T.: Atypical Facial Neuralgia, a Syndrome of Vascular Pain, Ann. Otol. Rhin. & Laryng. 41:1030-1062, 1932.

4. Helson, H.: The Part Played by the Sympathetic System as an Afferent Mechanism in the Region of the Trigeminus, Brain 55:114-121, 1932.

5. Hoffman, H. H.: An Analysis of the Sympathetic Trunk and Rami in the Cervical and Upper Thoracic Regions in Man, Ann. Surg., to be published.

6. Kuntz, A.: Nerve Fibers of Spinal and Vagus Origin Associated with the Cephalic Sympathetic Nerves, Ann. Otol. Rhin. & Laryng. 43:50-67, 1934.

7. Kuntz, A.: Distribution and Relationships of Sympathetic Ganglia in the Splanchnic Region, Tr. Am. Neurol. A. 80:88-91, 1956.

8. Kuntz, A.: Components of Splanchnic and Intermesenteric Nerves, J. Comp. Neurol. 105: 251-268, 1956.

9. Kuntz, A., and Main, L. R.: The Neural Basis of Certain Syndromes Associated with Dental Lesions, Arch. Clin. Oral Path. 4:333-344, 1940.

10. Lazorthes, G.: Le système neurovasculaire: Etude anatomique, physiologique, pathologique et chorurgicale, Paris, Masson & Cie, 1949.

11. Mitchell, G. A. G.: Rostral Extremities of the Sympathetic Trunks, Nature, London 170: 533-534, 1952.

12. Mitchell, G. A. G.: Anatomy of the Autonomic Nervous System, Edinburg, E. & S. Livingstone, Ltd., 1953.

13. Mizeres, N. J.: Isolation of the Cardioinhibitory Branches of the Right Vagus Nerve in the Dog, Anat. Rec. 123:437-445, 1955.

14. Ribes, F.: Exposé sommaire de quelques recherches anatomiques, physiologiques, et pathologiques, Mém. Soc. méd. emulation Lyon Pt. 2, pp. 604-630, 1816.

15. Streckfuss, H.: Untersuchungen über die ganglionäre Natur des Nervus splanchnicus major beim Menschen, Ztschr. ges. Anat. 96:473-487, 1931.

16. Terracol, J.: L'intérêt diagnostique des "douleurs rapportées" dans le territoire des nerfs craniens, Rev. oto-neuro-opth. 10:246-252, 1932.

Dimethicone (Silicone) Skin Protection in Surgical Patients

B. NOLAND CARTER II, M.D., and ROGER TALBOT SHERMAN, M.D., Cincinnati

Contact dermatoses develop frequently during the treatment of surgical patients with serious intra-abdominal disease. The procedures commonly responsible for these dermatoses are temporary or permanent exteriorization of open bowel, or drainage from within the peritoneal cavity to the outside, or both. Protection of the skin against contact irritants from intra-abdominal drainage of any form is a major part of the patient's care.

Many types of skin protectants, in the form of powders, ointments, and plastics, have been used on the surgical services of the Cincinnati General Hospital and the Children's Hospital in the past. None was found to be consistently effective.

This report is a clinical evaluation of the effectiveness of a dimethicone (silicone)-containing ointment as a skin protectant on the surgical services of the above hospitals over a seven-month period.

Materials and Methods

The ointment (Silicote) used in this study contains 30% of the silicones in a petrolatum base. As reported by Talbot et al.,[1] the silicones have a quartz-like chemical skeleton, consisting of alternating silicone and oxygen atoms. This construction is unlike organic compounds, which have a carbon-atom framework. The most useful property of the silicones from the standpoint of protection of the skin is that of extreme moisture repellency. Other important characteristics are chemical resistance,[2] low toxicity,[3] inertness, adherence, and thermal stability.

Submitted for publication Jan. 30, 1957.

From the Department of Surgery, University of Cincinnati College of Medicine, the Cincinnati General Hospital, and the Children's Hospital.

The Silicote Ointment used in this study was provided by Arnar-Stone Laboratories, Inc., Mount Prospect, Ill.

Shaw and Crowe[4] have reported that several silicone-containing preparations have been developed, differing greatly in the incorporated percentage of silicone fluids, as well as in the type of base in which they are incorporated. They further report that these differences modify the degree of protection exhibited by the mixtures against irritating or sensitizing materials and that a combination of 30% silicones in petrolatum gave superior results in providing protection to the skin against soap and water and soluble cutting oils. They concluded that an extension of results of these tests suggests that 30% silicones in petrolatum provides a superior protective against a wide range of aqueous materials, and further studies pertaining to particular aqueous irritants are suggested.

The present evaluation of this ointment, containing 30% dimethicone (silicone) in a petrolatum base, was begun in the spring of 1956. The patients selected for study were those with lesions requiring protection of the surrounding skin. Patients that died or were discharged before an adequate trial on dimethicone was completed are excluded from the study. A total of 13 types of lesions were studied. These were found among 61 surgical patients requiring skin protection from their various lesions. Application of the ointment to the skin was made as necessary, but generally at the time of dressing change. The severest areas of drainage required approximately three applications during a 24-hour period. The amount of ointment used on each application was dependent on the type of drainage. Upper gastrointestinal, biliary, or pancreatic lesions required a layer of approximately 0.5 cm. in thickness for protection of the surrounding skin. The remaining lesions, irrespective of type, were treated with dimethicone in a thickness necessary for skin coverage only.

Results

Listed in the Table are the results of the effectiveness of dimethicone in 61 surgical patients with 13 types of lesions. These results are classified by the terms excellent, good, fair, and poor. Definitions follow.

Fig. 1. — Twenty-one days after transverse colostomy. Excellent result.

Fig. 2. — Fifteen days after cecostomy. Excellent result.

Fig. 3. — Twenty-five days' draining pancreatic fistula — gunshot wound. Excellent result.

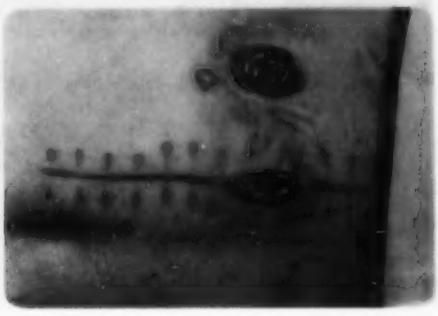


Fig. 4. — Thirty days after first-stage Lahey. Excellent result.

Results of Dimethicone Application with Thirteen Types of Surgical Lesions*

Type of Lesion	Excellent	Good	Fair	Poor	Total
Cecostomy	5	4	1	2	12
Colostomy	12	10	0	1	23
Biliary drainage	1	3	0	0	4
Ileostomy	2	0	0	0	2
Gastric drainage	1	0	0	0	1
Urinary fistula	0	1	0	0	1
Skin ulcers (Sodium hypochlorite, solution N.A., therapy)	6	3	0	0	9
Fecal fistula	0	0	0	2	2
Rectovaginal fistula	1	0	0	0	1
Draining perineum (after Miles operation)	1	0	0	0	1
Pancreatic fistula (gunshot wound)	1	0	0	0	1
Ileal bladder	3	0	0	0	3
Pancreatic abscess (lesser sac drainage)	1	0	0	0	1
Total lesions 13		Total patients 61			

* The appropriate percentages of the above results are 90% excellent to good, 2% fair, and 8% poor.

Excellent: Dimethicone-treated skin which retained its normal color, temperature, and consistency throughout the patient's hospitalization.

Good: Dimethicone-treated skin which reddened slightly but did not become excoriated throughout the patient's hospitalization.

Fair: Dimethicone-treated skin which became markedly reddened but did not become excoriated or weep throughout the patient's hospitalization.

Poor: Dimethicone-treated skin which progressed to excoriation and weeping in spite of diligent applications of dimethicone ointment.

Comment

Application of dimethicone in the immediate postoperative period, or as soon as the presenting lesion is discovered in the preoperative period, will give effective protection to the skin. The five poor results reported (Table) were in cases early in the trial series. Review of the records showed that there was a delay of 24 to 48 hours before dimethicone application in each case, either through a physician's or a nursing error. In each case, the skin was markedly reddened, and in several there was early excoriation, before dimethicone application was instituted.

The thickness of the ointment to be used for a specific lesion, as well as the frequency of application, must be determined by the physician in charge. It has been found in this series that a thickness of approximately 0.5 cm. applied frequently in the early stages of treatment is advantageous. Both may then be reduced as the amount and consistency of the discharge attain a more constant pattern. It is suggested that for the protection of ileostomy lesions, or other lesions in which the discharge is particularly excoriating, the first application of dimethicone ointment be applied at the time of surgery.

As has been found in any form of skin care, the medication used is not a substitute for diligent nursing routine. However, dimethicone has been found in this series to be an excellent adjuvant. No sensitivities resulted from the use of the material, and there was no indication of infection following its use.

Summary

A dimethicone-containing ointment (Silicote) has proved highly effective as a skin protectant in 90% of a selected group of surgical patients on the wards of the Cincinnati General Hospital and the Children's Hospital. These patients had lesions which produced continuous or intermittent drainage from either the alimentary or the genitourinary tract. Dimethicone was also found to be of value as a skin protectant from the discharge of cutaneous ulcers, as well as from medicaments used in their treatment. For best results, the ointment should be used as early as possible, before skin changes have taken place. Dimethicone is an excellent adjuvant, but not a substitute for diligent nursing care.

REFERENCES

1. Talbot, J. R.; MacGregor, J. K., and Crowe, F. W.: Use of Silicote as a Skin Protectant, J. Invest. Dermatology 17:125 (Nov.) 1951.

2. Dow Corning Silicone Note Book, Fluid Series No. 3, September, 1948, Dow Corning Corporation, Midland, Michigan, 1948.

3. Rowe, V. K.; Spencer, H. C., and Bass, S. L.: Toxicological Studies on Certain Commercial Silicones and Hydrolyzable Silane Intermediates, J. Indust. Hyg. & Toxicol. 30:332 (Nov.) 1948.

4. Shaw, J. M., and Crowe, F. W.: Skin-Protective Ointments: Comparative Study Including the New Silicone Preparations, A. M. A. Arch. Dermat. & Syph. 71:379 (March) 1955.

5. Morrow, G.: The Use of Silicones to Protect the Skin, California Med. 80:21 (Jan.) 1954.

Preoperative Chlorpromazine in Poor-Risk and Uncooperative Mentally Deficient Patients

Use in Patients Requiring Minor Surgical or Dental Care

THEODORE L. JACKSON, M.D.; JOHN M. CARSON, D.D.S., and GEORGE TARJAN, M.D., Pomona, Calif.

Introduction

Chlorpromazine * has been used in a variety of conditions, and many reports have appeared in the literature in recent years.[1-18] Between March and September of 1956 the drug was tried in uncooperative and poor-risk mentally deficient patients with the hope that its use would make surgery possible under local anesthesia.

The work was carried out at Pacific State Hospital, a state institution for the mentally deficient in California, with an average patient population of 2800, ranging in age from 1 to 75 years and in intelligence quotients from 2 to the high 70's.

Mentally deficient patients often resist even minor procedures under local anesthesia, and necessary cooperation cannot be obtained from them. Many have severe superimposed handicaps, manifested by involuntary muscle movements which interfere with treatment, although their relative high I. Q.'s should permit voluntary cooperation. General anesthesia or heavy sedation was therefore often necessary. The physical condition of the patient in many instances, however, contraindicated such undertaking. Barbiturates and opium derivatives frequently increased restlessness and uncooperativeness. Therefore needed corrective surgical and dental measures had to be postponed or cancelled.

A drug which would make these patients amenable to examination and/or operation without the need and hazards of a general anesthetic was considered a significant improvement in the over-all treatment program of the hospital. With these goals in mind, a pilot study using chlorpromazine was carried out on 25 consecutive cases.

Denhoff and Holden [1] described the requirements for a successful drug in cerebral palsy as one having beneficial effects on the child's over-all behavior, relaxant effects on musculature, palatability or ease of administration, and low toxicity. It was thought that chlorpromazine might prove successful in these respects also.

Experimental Problems

Several experimental difficulties were encountered. They may be summarized as follows:

1. *Use of Controls.*—It appeared impossible to find patients of the same age, sex, and I. Q. with the same degree of physical debility, the same surgical problem, and similar behavioral characteristics. Further, the chlorpromazine-treated patients could easily be identified by the observers because they often showed the so-called "chlorpromazine look" with an ashen appearance of the face, clamminess of the skin, a rapid, strong pulse, and well-filled veins. It was therefore decided to utilize each patient as his own control. The procedures were first attempted without the use of chlorpromazine and, secondly, after administration of the drug.

2. *Adequate Rating Scale.*—No proved rating scale was available to measure the changes in the behavior and cooperativeness of the patients. A simple method was de-

Submitted for publication Jan. 7, 1957.

* Thorazine (Smith, Kline & French Laboratories) was used in this study.

TABLE 1.—*Classification of Patients by Behavior*

Group 1	Group 2	Group 3	Group 4
Exhibited the majority of:	Exhibited the majority of:	Showed a combination of:	Showed a combination of:
Lay quietly	Moved about but could be controlled by verbal means	Moved about and could be controlled only with difficulty	Would not lie quietly
Answered questions as to pain	Did not respond to questions well but was not belligerent	Did not respond to questioning and was belligerent	Moved and thrashed about
Did not cry out or yell	Was mildly apprehensive but could be calmed	Was apprehensive	Was continuously belligerent
Held affected part cooperatively	Had mild physical manifestations of anxiety	Showed moderate signs of anxiety	Yelled and cried whether in obvious pain or not
Was not apprehensive			Was extremely apprehensive
Had no physical signs of anxiety			Showed many physical signs of anxiety
			No cooperation could be obtained

vised, classifying patients into four groups by the symptoms listed in Table 1. Such a subjective method of classification leaves much to be desired, but it proved useful for the purposes of this pilot study.

3. *Dosage.*—A definite dosage schedule was established: One-quarter milligram of chlorpromazine per pound of body weight was injected intramuscularly, not exceeding a maximum of 50 mg. This fixed schedule was decided upon so as to decrease the variables, even though in clinical practice better results may be obtained if the dosage were adjusted in accordance with the severity of the symptoms, in addition to the weight.

In 9 of the 25 cases, when intramuscular chlorpromazine did not produce results, oral tranquilization was attempted. The patients were placed on three days of medication, the daily amounts ranging from 10 to 75 mg. and administered in divided doses.

4. *Time Element.*—The onset and duration of tranquilization varied from patient to patient. For uniformity's sake, procedures were started one to one and a half hours after the injection, as soon as the patient appeared sufficiently tranquilized. Further experience may improve the timing of the injections.

5. *Personality of the Dentist or the Surgeon.*—The cooperativeness of the patient is dependent upon the ability of the dentist or surgeon to "sell" the procedure. In order to minimize this variable in the study, all surgical procedures were performed by the same surgeon (T. L. J.) and all dental procedures by the same dentist (J. M. C.).

6. *The Procedures.*—Tranquilization may be indicated in many procedures. To limit this variable, emphasis was placed on dental procedures such as examination, scaling, filling of cavities, and extractions. On 18 patients combinations of these procedures were performed. Seven had minor general surgical interventions.

7. *Classification by Anesthetic Risk.*—Chlorpromazine was to replace general anesthesia in poor-risk patients. Classification into four groups by anesthesia risk was therefore made. Group A (good risks) were those who showed no evidence of intercurrent diseases, chronic cardiorespiratory conditions, severe crippling deformities, or abnormal blood or urine findings. Into Group D (poor risks) were placed those who showed severe cardiorespiratory, liver or other disease; had severe crippling deformities; were chronically malnourished, or demonstrated abnormal laboratory findings. Groups B and C were intermediary cases between Groups A and D.

Results

Table 2 lists the cases and the results obtained. The patients ranged in age from 5 to 54 years, the largest number falling into the age group of 20 to 40; in I. Q.'s they ranged from 10 to 76, with a preponderance in the 20-to-50 range. Most patients were bad or poor anesthetic risks, falling into Groups C and D. Most were uncooperative prior to chlorpromazine administration and were classified in Groups 3 and 4 on the basis of their behavior.

TABLE 2.—*Preoperative Chlorpromazine in Poor-Risk and Uncooperative Patients*

Patient	Age, Yr.	I.Q.	IM Dose, Mg.	Blood Pressure		Behavior		Behavior After 3-Day Oral Therapy *
				Before	After	Before	After	
A	38	56	30	146/100	140/96	4	3	2
B	31	23	30	140/90	120/70	4	4	
C	28	Under 20	25	110/?	88/52	4	2	
D	40	42	35	140/92	122/88	4	4	1
E	38	17	30	120/74	106/64	3	3	1
F	36	27	25	122/74	100/72	2	1	
G	31	58	25	116/72	90/66	2	1	
H	21	46	30	110/80	120/80	4	2	
I	41	21	50	118/64	110/60	4	4	4
J	54	31	25	150/94	134/90	3	1	
K	12	76	18	128/88	100/68	3	2	
L	23	3	20	90/?	Unable to obtain	4	2	
M	13	48	25	110/70	104/70	2	1	
N	10	18	12.5	86/?	76/60	4	4	2
O	46	19	40	170/80	130/88	4	4	4
P	29	17	30	136/80	150/80	4	4	3
Q	30	46	30	120/80	108/70	3	1	
R	24	57	35	120/70	108/86	3	2	2
S	22	64	35	130/90	110/70	4	4	1
T	13	36	30	100/88	Unable to obtain	3	1	
U	13	47	25	108/78	118/80	3	1	
V	46	30	25	142/84	132/76	3	1	
W	25	46	25	120/70	104/64	3	1	
X	5	20	6	80/40	72/36	3	1	
Y	25	10	25	122/70	50/?	4	4	

* Where applicable.

The intramuscular dose of chlorpromazine ranged from 6 to 50 mg., the majority receiving between 25 and 30 mg. Sixteen patients received only one intramuscular injection; nine received additional oral medication. Nineteen, or 76% of the total, were considered successes. Four, or 16%, were failures (two of these received further oral medication). Two, or 8%, were judged as partial failures, both having received intramuscular and oral chlorpromazine. All the failures had an I. Q. below 25. The more outstanding results were obtained in patients with I. Q.'s of 40 or more.

No lasting complications were observed. The commonest side-effect was a drop in blood pressure, which in two patients bordered on brief circulatory collapse.

Sample Cases

CASE 1.—Patient D, aged 40, I. Q. 42, was extremely resistive, belligerent, and constantly moving. She refused to be led near the dental chair. She would fall on the floor, kicking and screaming. One hour after the intramuscular injection of 35 mg. of chlorpromazine she was still uncooperative. After three doses of oral medication she was cooperative, and the extraction of a partially impacted tooth was performed under local anesthesia without incident. On the following three visits no apprehension was noted, and the patient requested further dental care.

CASE 2.—Patient H, aged 21, I. Q. 46, was resistive and uncooperative to the extent that she fought the nurses and the dental personnel. She required physical restraint for the intramuscular administration of 30 mg. of chlorpromazine. After the drug was injected, she became more calm. She entered the dental chair and, although she resisted the dentist, the extraction of a tooth was accomplished under local anesthesia without incident.

CASE 3.—Patient J, aged 54, I. Q. 31, was an extremely apprehensive and resistive mentally deficient patient. She would not remain quiet and resisted even injections. She cried out and would not allow examination of a paronychia on her finger. One hour after 25 mg. of chlorpromazine intramuscularly the patient became quiet and cooperative and tolerated, without crying, manipulation of the involved area. Incision and drainage under local anesthetic were performed without difficulty. She returned for dressings daily without showing fear or apprehension.

Summary and Conclusions

The limited conclusions which can be drawn from this pilot study involving 25 mentally deficient patients imply that chlorpromazine is a useful preoperative tranquilizing drug.

The results were better in patients with higher intellectual capacities, suggesting that the drug may serve a useful purpose in apprehensive patients with normal mentality.

Oral medication for a few days prior to surgical intervention improved the results in some patients. Though this procedure should pose no problem when elective surgery is intended, a second intramuscular injection may be found simpler and of equal benefit.

In the dosages used in this study, drop in blood pressure was the only significant complication.

Potentiation of local anesthesia was not studied.

Pacific State Hospital, Box 100.

REFERENCES

1. Denhoff, E., and Holden, R. H.: The Effectiveness of Chlorpromazine (Thorazine) with Cerebral Palsied Children, J. Pediat. 47:328 (Sept.) 1955.

2. Loftus, L. R.; Huizenga, K. A.; Stauffer, M. H.; Rome, H. P., and Cain, J. C.: Jaundice Caused by Chlorpromazine, J. A. M. A. 157:1286 (April 9) 1955.

3. Gatski, R. L.: Chlorpromazine in the Treatment of Emotionally Maladjusted Children, J. A. M. A. 157:1298 (April 9) 1955.

4. Steigman, A. J., and Vallbona, C.: Chlorpromazine, a Useful Antiemetic in Pediatric Practice, J. Pediat. 46:296 (March) 1955.

5. Bair, H. V., and Herold, W.: Efficacy of Chlorpromazine in Hyperactive Mentally Retarded Children, A. M. A. Arch. Neurol. & Psychiat. 74:363 (Oct.) 1955.

6. Foster, C. A.; O'Mullane, E. J., and others; Chlorpromazine: A Study of Its Action on the Circulation in Man, Lancet 2:614 (Sept.) 1954.

7. Morris, G.; Mathews, W., and Moyer, J.: Clinical Experience with Chlorpromazine in Spinal Anesthesia, Anesth. & Analg. 33:340 (Sept.-Oct.) 1954.

8. Lear, E.; Chiron, A. E., and Pallin, I. M.: Chlorpromazine—An Adjunct to Premedication: Clinical Report Based on 1100 Cases, New York J. Med. 55:1853 (July 1) 1955.

9. Rees, E. L.: Metabolism of the Schizophrenic Child: Etiologic Hypothesis, J. Am. M. Women's A. 11:11 (Jan.) 1956.

10. Bourgeois-Gavardin, M.; Nowill, W. K.; Margolis, G., and Stephen, C. R.: Chlorpromazine: A Laboratory and Clinical Investigation, Anesthesiology 16:829 (Nov.) 1955.

11. Flaherty, J. A.: Effect of Chlorpromazine Medication on Children with Severe Emotional Disturbance, Delaware M. J. 27:180 (Aug.) 1955.

12. Elo, R., and Turunen, M.: Potentiation of Local Anesthesia by Largactil (M & B 2378) in Thoracoplasty, Ann. chir. et gynaec. Fenniae 44:10, 1955.

13. Cutright, E. G.: The Effects of Chlorpromazine Premedication on Anesthesia and Postanesthetic Symptoms, J. Am. M. Women's A. 11:45 (Feb.) 1956.

14. Dobkin, A. B.; Wehling, B.; Gross, G., and Mendelsohn, H.: Chlorpromazine in Anæsthesia, for Surgical Treatment of Pulmonary Tuberculosis, Anæsthesia 10:328 (Oct.) 1955.

15. Downey, P. G.; Hansen, J. M.; Morkane, C. J. J.; Pryor, and Taylor, E. H. H.; Chlorpromazine Premedication: Preliminary Report, New Zealand M. J. 54:213 (April) 1955.

16. Lipton, B., and Hershey, S. G.: Chlorpromazine as an Adjunct to Spinal Anesthesia, New York J. Med. 55:2463 (Sept.) 1955.

17. Mathews, W. A.; Morris, G. C., Jr., and Moyer, J. H.: Use of Chlorpromazine in Anesthesia, Am. Pract. & Digest Treat. 6:360 (March) 1955.

18. Rettig, J. H.; Chlorpromazine for the Control of Psychomotor Excitement in the Mentally Deficient: A Preliminary Study, J. Nerv. & Ment. Dis. 122:190 (Aug.) 1955.

Primary Carcinoma of the Appendix

An Incidental Finding During Laparotomy

JACOB RABINOVITCH, M.D., C.M., Brooklyn; PHINEAS RABINOVITCH, M.D., C.M., Montreal, Canada; PHILIP ROSENBLATT, M.D., and HARRY ZISK, M.D., Brooklyn

The rarity of primary carcinoma of the appendix has been pointed out by most authors writing on the subject. Consequently, general surgical textbooks make scant reference to the condition, and any large series studied of necessity has to be taken from the surgical literature. Few cases, indeed, occur in the surgical experience of one person, and these are usually published as isolated case reports because of their rarity. For this reason, also, statistical studies on the frequency of occurrence of these appendiceal tumors are in most instances inaccurate.

There are no pathognomonic signs or symptoms of primary carcinoma of the appendix. It has been pointed out that with appendiceal neoplasms the clinical signs may be noteworthy by their absence, often despite large tumor growths. Even when dealing with a symptom-producing tumor, the physician is rarely able to establish a correct diagnosis before operation, and the operating surgeon may share in this difficulty even after having viewed the lesion at the operating table. In some instances abdominal symptoms are produced as a result of superimposed acute inflammation of the appendix which follows constriction of the lumen by the invading neoplasm with distal suppuration or by perforation of the viscus. Acute appendcitis is therefore not an infrequent complication of appendiceal carcinoma.

The purpose of the present paper is to record our experiences and the results of treatments in four cases of carcinoma of the appendix, rather than to describe all aspects of this unusual condition. Certain features of the disease as they relate to the diagnosis, management, and pathology will receive special emphasis.

This presentation embodies a study of four cases of primary carcinoma of the appendix discovered accidentally during the performance of a laparotomy done for another lesion. In none of these cases was the diagnosis of carcinoma of the appendix made preoperatively. The actual diagnosis was made only after histologic examination of the resected specimen.

Report of Cases

CASE 1.—A white woman aged 54 was admitted to the hospital with the complaint of right upper abdominal pain, nausea, and vomiting of 24 hours' duration. She had had similar but milder attacks of pain for the past few years, but latterly the attacks were more frequent and more acute, often requiring morphine for the relief of pain. The pain frequently radiated to the back and between the shoulder blades. She had no other symptoms referable to the digestive tract.

On physical examination at the time of admission to the hospital the patient did not appear acutely ill. There was a moderate degree of tenderness and muscle resistance in the right upper abdomen. Elsewhere the abdomen was soft, not tender or distended; the gallbladder could not be palpated. The blood count, urinalysis, and liver function tests were within normal limits. Cholecystograms revealed the presence of multiple stones within the gallbladder cavity.

The clinical impression was that the patient was suffering from chronic cholecystitis and cholelithiasis, for which removal of the gallbladder was deemed necessary.

At operation, through a right subcostal incision, the gallbladder was found moderately enlarged,

Submitted for publication Jan. 31, 1957.

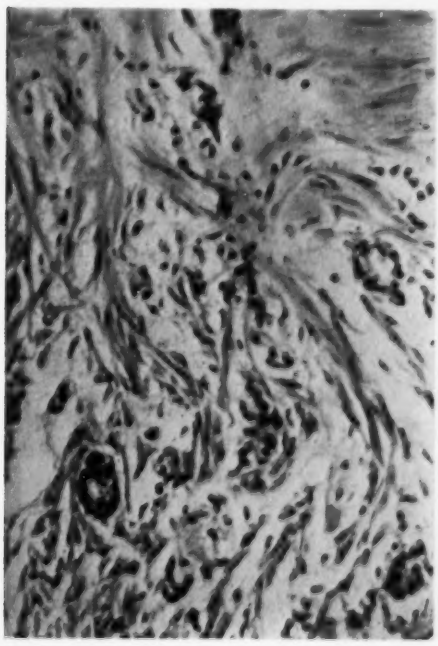
From the Adelphi Hospital, Brooklyn, and the Mount Royal Hospital, Montreal.

its wall thickened, and its cavity filled with stones; a cholecystectomy was therefore done. The appendix was readily accessible, and, when exteriorized, its wall was found much thickened except at the base, where it was of normal appearance. The impression gained at the operating table was that the appendix was the seat of a chronic inflammatory lesion. An appendectomy was done without inverting the stump into the cecum.

Pathologic examination of the gallbladder showed evidence of chronic cholecystitis and cholelithiasis.

Aside from increased thickening of the wall, the appendix showed nothing remarkable on gross inspection. In the cut surface the lumen was indistinguishable and the wall was thickened, gray, and firm. Microscopic examination revealed that the lumen of the appendix was obliterated by dense fibrous tissue, which extended into the thickened muscle layer. The submucosa was represented by scattered lymphoid cells, which sometimes arranged themselves into follicles. Streaming into the muscle layer and serosa from the mucosal surface were nests of small, deeply stained epithelial cells, which sometimes arranged themselves about lumens in gland-like patterns. These cells had hyperchromatic nuclei, which varied in size and shape. The cytoplasm was scant, granular, and eosinophilic. In places individual cells had a signet-ring appearance. Mucin was seen in some of the lumens and at times also in the periphery of the lining cells. Mitotic figures were noteworthily absent. There was a marked desmoplastic reaction, especially in the serous layer. The pathologic diagnosis was that of an infiltrative (scirrhus) mucous-cell carcinoma of the appendix (Fig. 1).

Fig. 1.—Photomicrograph showing scirrhus carcinoma of the appendix. The section shows mucus-secreting gland scattered in a stroma of dense fibrous connective tissue. Reduced to 59% of mag. × 140.



The patient made a good postoperative recovery and was discharged from the hospital on the 10th day following operation. However, because of the findings in the appendix, coupled with the fact that the stump of the appendix was left in situ, it was felt that the right half of the colon should be removed. Consequently, the patient was readmitted to the hospital four weeks later, and a right hemicolectomy was done. At this operation no carcinomatous tissue could be found anywhere in the bowel, adjoining lymph nodes, or distant organs. The stump of the appendix was entirely replaced by scar tissue and could not be identified even on microscopic examination of the specimen. At the time of this writing, more than a year since operation, the patient is well and free from symptoms.

Case 2.—A 52-year-old housewife was admitted to the hospital with the chief complaint of prolonged and profuse menstrual bleeding. She had been in good health until six months prior to this admission, when she began to note that her menses were prolonged and that the menstrual flow was excessive. This was associated with pallor and considerable weakness.

On admission, the general examination was not remarkable except for the apparent pallor of the skin and mucous membranes. Abdominal and pelvic examination disclosed the presence of a large tumor mass arising from the body of the uterus and filling the pelvic cavity. The blood pressure was 135/80. Laboratory findings were as follows: Wassermann reaction, negative; hemoglobin 60%; red blood cells 3,200,000 and white blood cell count 9,000 per cubic millimeter, with normal distribution of cells.

The clinical diagnosis was that of fibroids of the uterus and secondary anemia. The patient was given a blood transfusion and the abdomen explored. The uterus was the seat of multiple leiomyomatous growths, located both in the submucosa and subserously. A total hysterectomy was done, followed by removal of the appendix. The latter was much thicker than normal; the increase in thickness was attributed at the time of operation to a chronic inflammatory process and muscular hypertrophy.

The gross and microscopic examination of the tumors in the uterus gave findings characteristic of benign leiomyoma.

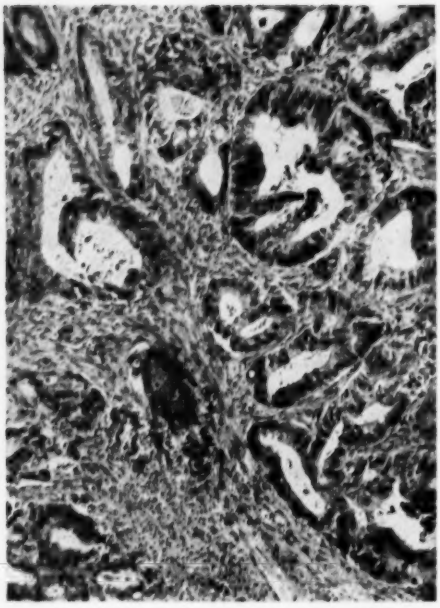


Fig. 2.—Photomicrograph demonstrating an adenocarcinoma of the appendix. Reduced to 64% of mag. × 140.

Grossly, aside from increased thickening of the wall, the appendix showed nothing of note. Microscopically, however, there was found a tumor arising from the mucosa, which had the histologic features of adenocarcinoma (Fig. 2).

The patient recovered well from the operation and was operated upon three weeks later for removal of the right half of the colon. At the time of the second operation no evidence of carcinoma could be found anywhere in the bowel, lymph nodes, or other abdominal viscera. To date, eight years since the operation, the patient is alive and well.

CASE 3.—A 62-year-old man was admitted to the hospital with the complaint of severe pain in the right groin of several hours' duration. He had had a femoral hernia for many years, which caused no symptoms until the present episode of pain. The hernia was always kept reduced with the aid of a truss, which he had worn for many years. Since the onset of the present attack he could not reduce the hernia; it had become very painful and tender.

Physical examination on admission to the hospital disclosed a rather ill man, complaining of severe pain in the right groin. In the right femoral region there was found a moderate sized hernia, which was very tense, tender, and nonreducible. The clinical impression was that of a strangulated right femoral hernia.

At operation, performed shortly after admission to the hospital, there was found a strangulated right femoral hernia. The sac was thickened, edematous, and of a blue discoloration. It contained, in addition to a small amount of hemorrhagic fluid, a strangulated appendix; the latter was considerably enlarged, edematous, and intensely hemorrhagic. The appendix was therefore removed and the hernia repaired. Recovery was uneventful.

Pathologic examination of the appendix showed considerable mural thickening involving the distal two-thirds of the organ. The serous surface was intensely hemorrhagic throughout.

Microscopically, the blood vessels were seen to be dilated and engorged with blood; some of the vessels were occluded by thrombi. In addition, there was found a carcinoma arising from the mucosa of the appendix and infiltrating the muscular layer. The parenchyma of the tumor consisted of gland-like structures lined by tall columnar epithelium, containing bizarre-shaped and hyperchromatic nuclei. Some of the cells showed mitotic changes. The pathologic diagnosis was that of adenocarcinoma of the appendix (Fig. 3).

The patient was advised to undergo a secondary operation for the removal of the right colon, but he refused additional surgery. To date, 12 years since the operation, the patient is reported to be still alive and free from symptoms.

Fig. 3.—Adenocarcinoma of the appendix. Note the gland-like structures with lumens lined by tall columnar epithelium. Reduced to 64% of mag. × 140.

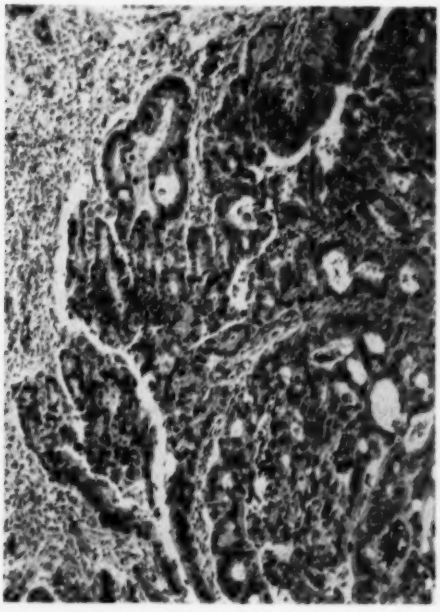
CASE 4.—A 48-year-old man was admitted to the hospital with the main complaint of severe right lower abdominal pain of 12 hours' duration. At the onset the pain was in the midabdomen, but it later settled in the right lower quadrant of the abdomen, where it persisted with increasing severity. There was nausea but no vomiting.

Examination on admission disclosed a rather ill patient, complaining of continuous pain in the right lower abdomen. There was point tenderness, release pain, and muscle resistance over McBurney's point. No masses could be felt abdominally or on rectal examination. There was leukocytosis, with a count of 16,000 white blood cells, 90% of which were polymorphonuclear leukocytes. The clinical impression was that of acute appendicitis, for which surgery was advised.

At operation through a McBurney, muscle-splitting incision, the abdominal cavity was opened and explored. A small amount of turbid fluid was found between the cecum and the lateral abdominal wall. The appendix was acutely inflamed; its wall was thickened and edematous, and the serosa was intensely hemorrhagic and covered with a purulent exudate. An appendectomy was done, and the abdominal wound was closed without drainage of the peritoneal cavity. The patient made a smooth recovery.

Grossly, the appendix showed evidence of acute appendicitis. Histologically, the appendix showed, in addition to an acute inflammatory process, a carcinomatous lesion, which had arisen from the mucosa, invaded the lumen, and occluded it. The growth was typically adenocarcinomatous in nature and was made up of gland-like structures lined by tall epithelium. Many of the cells were mucus-secreting, and some showed mitotic figures (Fig. 4).

Fig. 4.—Photomicrograph showing adenocarcinoma of the appendix and an acute inflammatory-cell exudate. Reduced to 64% of mag. × 140.



Because of the malignant nature of the growth, a right hemicolectomy was deemed advisable. On reoperation two weeks later, no evidence of residual or metastatic carcinoma could be found anywhere in the bowel or other viscera. A right ileocolectomy was done, followed by an ileotransversocolostomy; recovery was uncomplicated. At the time of writing, five years since operation, the patient is alive and well.

Evaluation

A review of the cases cited in this paper and those reported in the literature demonstrates clearly that the diagnosis of carcinoma of the appendix is often beset with many difficulties. It is also to be noted that the tumor in all of the cases described above was an incidental and unexpected finding at laparotomy. In none of the patients was the diagnosis made, or even suspected, prior to operation, nor was a correct interpretation of the changes noted in the appendix made by the operator when he viewed the lesion at the operating table. It seems, therefore, that, unless obvious metastases are present, it is extremely difficult to distinguish a malignancy of the appendix from chronic inflammation or from some other disease process, even at exploration. Being a most unusual condition, it is not suspected even at laparotomy. This point is stressed because the lesion may easily be overlooked at the primary operation, and this oversight may cause confusion later on because of further symptoms and has been responsible for inadequate surgery in a number of cases.

There is no notable sex predilection for these neoplasms of the appendix, although, according to reports in the literature, females may be slightly to the fore. It is explained, however, that the apparent preponderance of the lesion in females is due to the fact that more women undergo

laparotomies than men, and hence, also, more routine appendectomies are done in women than in men. Our series is too small for statistical analysis; but of the four patients reported on here, two were men and two were women, showing an equal distribution of the lesion in the two sexes. The majority of these tumors have been reported to occur between the ages of 50 and 60 years, but the age incidence may be wide, ranging in this series between 48 and 62, with an average of 54 years.

The clinical and pathological findings noted in our group of patients are very similar to those described by most authors and require, therefore, very little additional comment. A few points, however, may be emphasized to advantage. As already noted, none of our patients showed, even remotely, any signs or symptoms suggestive of carcinoma of the appendix. In the first two patients the appendix was removed as a routine procedure which we commonly pursue while doing a laparotomy. In the third case the appendix became strangulated in a femoral hernia and of necessity had to be removed, whereas in the fourth case acute appendicitis developed secondary to obstruction of the lumen of the appendix by the tumor and an appendectomy had to be done. Needless to say, had a routine appendectomy not been done in the first two cases, and had an emergency appendectomy not been done in the last two cases, the lesion in the appendix would have been left unrecognized. There is no doubt that this early extirpation of the appendiceal tumor has removed the risk of spread of the disease and has ensured a better outlook for these patients. This we consider is prophylactic surgery in the true sense of the word.

Histologically, most cancers of the appendix are adenocarcinomatous in type. The close similarity in both architectural pattern and cell morphology of the carcinomatous cells to cells of the mucosal glands of the appendix is striking and at once suggests a genetic relationship. The parenchyma of these tumors usually consists of gland-like structures lined by tall columnar epithelium. Cytoplasmic activity is often characterized by the formation of mucin, which may fill the cell or the lumen of the gland. Active growth is frequently typified by cell mitoses, which may be widespread in the more rapidly growing and metastasizing tumors.

Tumors of the appendix may fall into two groups, namely, those which grow toward the lumen and those which grow toward the mesentery. Most of the latter group are the more malignant. For mechanical reasons alone a higher incidence of appendiceal obstruction is to be expected in the first group. As has already been pointed out, the tendency for the first group to grow toward the lumen frequently accounts for the obstruction and secondary development of acute appendicitis.

Carcinoma of the appendix is as a rule a primary lesion and for a long time confines its growth to that organ. As the disease progresses, the growth extends into the muscular wall, but its tendency is to localize in the appendix, and not to metastasize. In some instances, however, it tends to spread into adjoining structures, especially into the cecum, in which case it interrupts the muscularis mucosae and continues its course beneath it. Distant metastasis to lymph nodes and viscera, especially to the ovaries, may also occur in the more advanced stages of the disease.

Surgeons wish to know from experience gained from proved results what the most effective treatment is for a given condition. Because appendiceal tumors are usually slow-growing, they offer some hope for surgical arrest. The pathologic characteristics of these rare neoplasms affect the type of surgical therapy which should be adopted. Every patient, however, should be treated on the merits of his or her case; but, from the study of the literature, certain generalizations can be made. Since these tumors are so uncommon, no one surgical center can offer a large series susceptible to statistical analysis. There is general agreement that

the treatment of carcinoma of the appendix is surgical, roentgen therapy being of little value. The growth peculiarities of these rare tumors are such that a right hemicolectomy should offer certain of these patients a favorable outlook. The chances of permanent arrest of these lesions by radical surgery would certainly seem better than is the situation with cancer of the rest of the large bowel, where spread beyond the limits of resection occurs early. Lesnick and Miller [1] urge that a right hemicolectomy be carried out in all cases of carcinoma of the appendix, for they feel that any less radical procedure entails too great a risk of recurrence. Some surgeons feel, however, that a more conservative removal with a generous margin of adjoining cecum is sufficient.

Although reported experience is too limited for evaluation of prognosis, these few reports appear to justify vigorous surgical attempts at extirpating these neoplasms. We feel that radical surgery, which means the performance of a right hemicolectomy, should be undertaken as a primary procedure whenever the diagnosis can be established at the time of initial exploration. If the diagnosis is manifest only after microscopic examination of the excised specimen, the ileocolic resection should follow as a second stage as soon as the patient's condition will permit.

In the present series a secondary hemicolectomy was done in three patients after histologic examination of the appendix revealed the presence of carcinoma. These three patients are still alive and well one to eight years following radical extirpation of the lesion. The fourth patient is alive and well 12 years following a simple removal of the appendix. It seems that in cases where the lesion has not transgressed beyond the limits of the appendix, the mere removal of the diseased organ may be sufficient to affect a long cure.

Summary

The incidental discovery of a primary carcinoma of the appendix during laparotomy for some other disease condition is a very rare occurrence. Four such cases are reported in this paper.

The intraluminal tumors are the lesions which extend into the lumen, where they may produce obstruction and secondary acute inflammation of the appendix. All other carcinomas of the appendix are nonproductive of symptoms and can therefore not be accurately diagnosed before operation.

There is general agreement that metastases in cases of carcinoma of the appendix are late and that these tumors infiltrate less extensively than do colonic carcinomas.

A general review of the literature shows rather poor results with local management of even the apparently less malignant lesions. It is generally felt that the more radical procedure, such as a right hemicolectomy, is justified in order to improve the prognosis.

The prognosis for carcinoma of the appendix has never been well established, for too few long-term reports are available. In the present series three patients are alive one, five, and eight years, respectively, following appendectomy and right hemicolectomy. In the remaining patient an appendectomy alone was done; he is alive and well 12 years later.

1221 Albemarle Rd., Brooklyn (18) (Dr. Rabinovitch).

REFERENCE

1. Lesnick, G., and Miller, D.: Adenocarcinoma of the Appendix, Cancer 2:18, 1949.

Ileal Transplant to Produce Perineal Stoma After Abdominoperineal Resection

HERBERT F. NEWMAN, M.D., New York

The abdominal colostomy gives a satisfactory functional result and, with adequate discipline, does not require any appliance or receptacle. Some patients adamantly refuse this component of the abdominoperineal resection and perforce have been subjected to a sphincter-saving operation which may not be adequate from a tumor standpoint. In several of these cases the mobilized descending colon has been brought to the perineum. A perineal colostomy may function as well as one implanted in the abdominal wall, but, in the absence of both the terminal rectal segment and the sphincter, leakage is common, and there is no mechanism to restrain the occasional peristaltic rush.

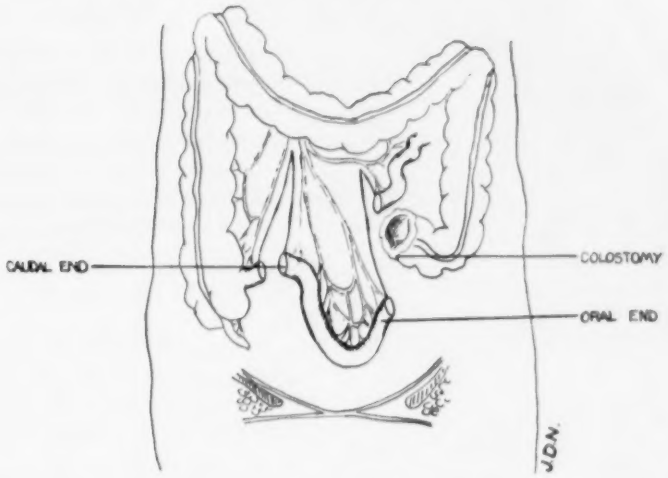
Interposed ileal segments have been clinically employed to span large gaps between colon and rectum where a direct anastomosis was not technically feasible. In Finsterer's review of 1952, fifty-two such operations, with only six deaths, had been reported in the world's literature.[1] Experiments in dogs[2-4] indicate that the small bowel, transplanted with an intact blood and nerve supply, maintains its normal motility pattern. Haberland[2] stressed the danger of interposing an antiperistaltically directed ileal loop, for his animals developed fatal ulceration and perforation at the proximal anastomotic level. More recent studies indicate that the interposition of a reversed bowel segment is compatible with life but produces a distinct delay in the transit of intestinal contents.[3]

Inasmuch as there was entertained the possibility that a reversed segment of ileum, retaining its intrinsic intestinal gradient, might act as a functional sphincter, the following operation was performed.

On Dec. 30, 1954, a Miles abdominoperineal resection was performed on a 64-year-old man for an adenocarcinoma of the rectum located 6 cm. above the pectinate line. A Cherney incision was employed, and the descending colon was brought out as a terminal colostomy, 2.5 cm. below and to the left of the umbilicus. The postoperative course was relatively benign. On June 6, 1956, the patient was reexplored through a vertical, lower abdominal incision centered over the middle of the right rectus. The entire abdominal cavity and pelvis were found free of disease. Forty centimeters from the ileocecal junction a segment of ileum, 25 cm. long, was isolated, the incisions being carried into the mesentery beyond the most peripheral arterial arcade. Small bowel continuity was established anterior to this loop by a two-layer end-to-end anastomosis. Through a stab wound placed several millimeters below the colostomy, the caudal end of the isolated ileal segment was brought to the skin with a De Martel clamp. This produced a clockwise torsion of its vascular pedicle to 110 degrees without visible change in the color of the bowel. A double-barreled coloenterostomy was effected by suturing the two limbs together with two rows of interrupted nonabsorable seromuscular surgical sutures for a distance of 9 cm. The oral end of the ileal segment was closed with a nonabsorbable purse-string surgical suture whose ends were kept long. The patient's thighs were flexed, and an assistant incised the perineum for a distance of 3 cm. at the site of the previously removed anus. By means of a long clamp passed through this incision, he grasped the long nonabsorbable guide sutures and drew the oral end of the ileal segment out of the perineal wound for a distance of 5 mm. The abdominal cavity was closed. The protruding segment of ileum on the perineum was opened, and the bowel sutured to the skin with interrupted nonabsorbable surgical sutures.

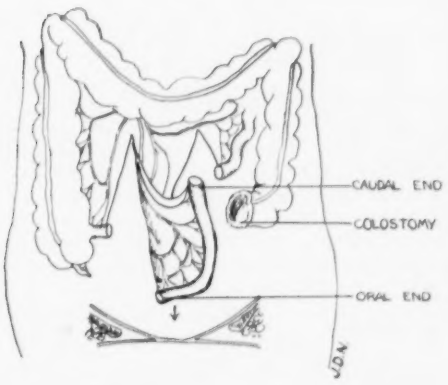
The patient had a spontaneous bowel movement through the colostomy on the third postoperative day. Three days later a Devine spur crusher was applied, and within five days there was a wide

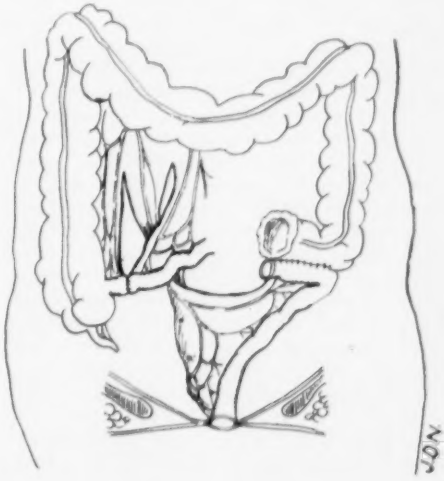
Submitted for publication Nov. 29, 1956.

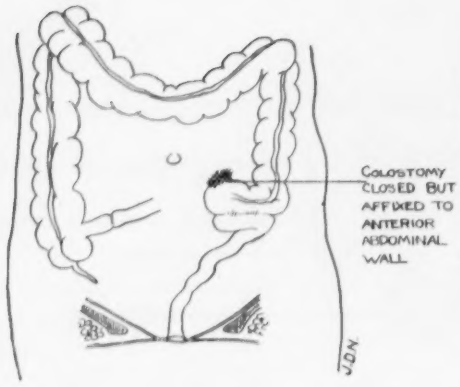


communication between the descending colon and the transplanted small bowel. On the 12th postoperative day 2 oz. of water was slowly instilled through the abdominal enterostomy into the distal ileal segment. None escaped through the perineal opening, but the entire amount was forcibly ejected by antiperistalsis out of the abdominal stoma. On July 2, 1956, an attempt at extraperitoneal closure of the coloileostomy failed, and the patient continued to discharge all feces through the colostomy despite the free access to the transplanted small bowel. On Aug. 24, 1956, the abdomen was reopened, and an intraperitoneal closure of the coloenterostomy effected. The colon was left attached to the anterior abdominal wall to avoid any further torsion of the pedicle to the ileal transplant.

The patient's first bowel movement through the artificial perineal anus followed a generous enema on the fourth day after colostomy closure. His subsequent course has been followed with interest. There has never been a spontaneous bowel movement or leakage of feces, although on one occasion he avoided enemas for three days. An enema of 1 qt. of water is retained completely, and emptying of the colon requires the instillation of 3 to 4 qts. of fluid. His only complaint has been "constipation". Roengten studies were performed two months after the closure of the colostomy. Barium instilled into the artificial anus flowed freely up to the cecum without evidence of stenosis at the anastomotic level. On evacuation, there was a distinct delay of at least 30 minutes at the coloileal junction with discomfort described as "gas pains".







There has been no excoriation of the skin about the perineum, but the ileal transplant prolapses on straining for a distance of 2 cm.

This procedure has produced a satisfactory functional result, which is no better than that gained by a good abdominal colostomy, for both require regular enemas. Its dubious virtue of a perineal location may hold a place in the radical treatment of rectal carcinoma where the patient refuses an abdominal colostomy.

Summary

A patient with an abdominal colostomy following a radical abdominoperineal resection was given a perineal stoma by an ileal transplant. The reversed direction of the transplant acted as a functional sphincter. The procedure may hold a place in the treatment of low rectal neoplasms where an abdominal colostomy is refused.

60 E. 75th St. (21)

REFERENCES

1. Finsterer, H.: Dünndarmzwischenschaltung zur Wiederherstellung der Kontinenz nach Colon- und Rectumresektionen, Arch. klin. Chir. 271:337, 1952.

2. Haberland, H. F. O.: Die Einpflanzung eines gestielten Dünndarmstückes in den Dickdarm, Beitr. klin. Chir. 149:432, 1930.

3. Hammer, J. M.; Seay, P. H.; Hill, E. J.; Prust, F. W., and Campbell, R. B.: Intestinal Segments as Internal Pedicle Grafts, A. M. A. Arch. Surg. 71-625, 1955.

4. Thompson, J. A., and Watman, R. N.: Behavior and Fate of Ileal Segments Interposed in the Left Colon, A. M. A. Arch. Surg. 73:645, 1956.

Omphalocele in Siblings

Report of Two Cases with Surgical Recovery

ROBERT E. ROTHENBERG, M.D., and THEODORE BARNETT, M.D., Brooklyn

True omphalocele may best be described as a herniation of abdominal viscera through the umbilicus, in which the sac is composed only of a clear, thin membrane. O'Leary and Clymer [1] summarized several reports of collected cases and concluded that the incidence is approximately 1 in 3,500 births. Their review of the literature indicated that omphalocele is twice as common among males.

Although most authors believe that there is little tendency toward a familial incidence of this anomaly, several reports of true omphalocele among siblings have been uncovered. Paucot and Gellé [2] in 1936 recorded three successive stillborn fetuses of a syphilitic mother, who had large omphaloceles. McKeown, MacMahon, and Record [3] found one instance of omphalocele among siblings in a study of 62 families in which this condition existed. A thorough search of the literature would indicate that the patients reported herein are the only ones in which large omphaloceles were present in siblings and in which survival followed surgical intervention.

Report of Cases

CASE 1.—This patient, a female infant, was born of healthy Negro parents on Dec. 13, 1953, at the Jewish Hospital of Brooklyn. The only abnormality on thorough examination of the parents was a Darwinian tubercle anterior to the mother's right ear. The infant was full-term and was delivered with low forceps after a normal three-hour labor. This was the mother's first pregnancy. Birth weight was 7 lb. 10 oz. An omphalocele with an intact sac measuring 3 by 4 in. was noted. Through the transparent sac one could see the liver, splen, stomach, large and small bowel. Three hours after birth, under general anesthesia, large skin flaps were mobilized from the surrounding abdominal wall and were sutured so that they completely covered the omphalocele. No attempt at repositing the sac contents within the peritoneal cavity was made. The postoperative course was satisfactory, except that a few small areas of necrosis of the skin suture line with subcutaneous infection took place. A separation of skin edges measuring approximately 1½ in. in diameter was noted on the 11th day after surgery, but the thickened sac wall remained intact, and no abdominal contents protruded. Twenty days after birth a secondary closure with remobilization of skin flaps was performed. However, this procedure was not effective, and 10 days after the operation separation of skin edges again took place. Accordingly, 39 days after birth a full-thickness skin graft from the right lower chest wall was placed into the residual defect which measured about 1½ in. in diameter. Approximately 80% of this graft remained intact, and the infant was discharged from the hospital on Feb. 3, 1953, with the entire scar healed except for an area measuring about ¼ in. in diameter. This area healed within three weeks after hospital discharge.

The infant underwent normal first-year development. At 28 months of age the contents of the large residual ventral hernia were readily reducible into the peritoneal cavity, and accordingly on April 19, 1955, the second stage of the operation was performed. At operation the hernial defect was found to measure 6 by 3 in. No adhesions were present between the viscera and the hernia sac. The redundant skin and sac were excised, and hernia repair was accomplished by simple side-to-side suturing of the peritoneum and posterior rectus sheath with interrupted chromic absorbable surgical (gut) sutures. The anterior rectus sheaths were then sutured in side-to-side fashion with interrupted mattress chromic gut sutures. The postoperative course was uneventful. When last examined, on March 29, 1956, the abdominal wall was firmly healed and there was no evidence of recurrence (Figs. 1 and 2).

CASE 2.—The sister of the first child, was born on Jan. 13, 1955. The mother has had no preg-

Submitted for publication Nov. 8, 1956.

From the Department of Surgery of the Central Medical Group of Brooklyn.

Fig. 1.—Patient 1, at 28 months of age, just prior to second-stage operation for repair of the ventral hernia.

nancies other than the children reported herein. Birth weight was 7 lb. 6 oz. and delivery was assisted with low forceps after a two-and-one-half-hour normal labor. At birth a ruptured omphalocele measuring 4 by 5 in. in diameter was found. The stomach, spleen, entire small intestine and large intestine, and inferior portion of the liver were all external to the abdominal cavity and were lying free on the abdominal wall. The obstetrician was astounded to note that the child was alive. Within an hour after birth, under general anesthesia, an attempt was made to reposit the viscera into the ruptured omphalocele sac and to suture the membrane. This was accomplished with great difficulty because of the extreme friability of the membrane and because of its extensive laceration. The surrounding skin was then freed subcutaneously from just below the nipples down onto the anterior aspect of the thighs and laterally around the flanks almost to the posterior midline. Several relaxing incisions had to be made radially in order to get the mobilized skin to cover the omphalocele membrane. The postoperative course was smooth, with slow but excellent wound healing. The child was discharged with a completely healed wound on the 65th postoperative day.

This infant has developed normally, and when last seen on March 1, 1957, the scars were well healed, but it was felt that the abdomen had not enlarged sufficiently to permit the second stage operation to be performed (Fig. 3).

Comment

In both of our cases it was decided to perform a two-stage operation. Gross [4] points out that unless the omphalocele is small the one-stage procedure of repositing the contents in the peritoneal cavity and repairing the abdominal wall is attended by high mortality. This is due chiefly to the fact that the abdominal cavity is not large enough to accommodate the eviscerated organs. Death

Fig. 2.—Patient 1 after surgical repair of ventral hernia.

Fig. 3.—Patient 2, at 3 months of age, showing large ventral hernia with overlying skin completely healed.

may result from hypoventilation, interference with vena caval filling, or intestinal obstruction. Thus, it has been suggested that the preliminary operation should limit itself to covering the omphalocele sac with skin. This procedure gives the viscera the protection of a cutaneous coat, and, although it may leave a large bulging hernial mass, such a condition is compatible with life. Some months or years later, when the abdominal cavity has grown sufficiently to receive the intestinal contents, secondary repair may be performed. It is surprising that upon performing the secondary operation the peritoneal cavity and sac are often found to be free of adhesions.

In our first case it was necessary to use a skin graft to obtain complete cutaneous coverage. However, the initial covering remained intact long enough to permit the omphalocele membrane to thicken and to protect the underlying viscera. When partial skin separation occurred some 11 days after operation, the omphalocele membrane did not rupture, nor did it protrude above the cutaneous level. The second case was complicated by the fact that the child was born with a ruptured omphalocele sac. Prior to 1940 no instances of recovery in this type of case were reported. With the use of the two-stage operation and with the advent of the antibiotic drugs and the consequent reduction in postoperative peritonitis, a survival rate of 33% can now be anticipated.

The literature states that approximately 33% to 55% of infants born with omphalocele have associated abnormalities, such as anencephaly, congenital heart disease, malrotation of the bowel, harelip, or mongolism. The two children reported herein have no other congenital abnormalities.

Summary and Conclusions

Two cases of omphalocele in siblings with surgical recovery are reported. Immediate surgery to cover the omphalocele with skin is advocated. Repair of the hernial defect should be delayed for several months or years until the abdominal cavity has grown sufficiently to accommodate the hernial contents.

345 Schermerhorn St. (17)

REFERENCES

1. O'Leary, C. M., and Clymer, C. E.: Umbilical Hernia, Am. J. Surg. 52:38 (April) 1941.

2. Paucot, H., and Gellé, P.: Hernie ombilicale embryonnaire récidivante chez 3 fœtus successifs, Bull. Soc. d'obst. et de gynéc. 25:294 (April) 1936.

3. McKeown, T.; MacMahon, B., and Record, R. G.: An Investigation of 69 Cases of Exomphalos, Am. J. Human Genet. 5:168 (June) 1953.

4. Gross, R. E.: New Method for Surgical Treatment of Large Omphaloceles, Surgery 24:277 (Aug.) 1948.

Plunging Goiter Made Evident by Valsalva's Maneuver

EVERETT SHOCKET, M.D., and THEODORE R. HUDSON, M.D., Chicago

Extension of a cervical goiter to just beneath the sternum has been variously reported as occurring in 7%,[1] 12%,[2] and 21%[3] of all goiters operated on. Since minor substernal extension does not significantly modify the surgical attack, Wakeley and Mulvany[1] suggested that the term "intrathoracic goiter" not be applied to this slightly substernal group but rather that the term be reserved for those unique goiters which lie entirely or mostly inferior to the thoracic inlet. Those entirely below the inlet are referred to as being totally intrathoracic. Those mostly below the inlet are called partially intrathoracic. When these more stringent criteria are employed, the incidence of intrathoracic goiter drops to between 1.7%[1] and 3%.[4]

The Lahey thesis[3] that the anatomical arrangement of its environs limits anterior spread of an expanding adenomatous goiter but permits inferior spread along a plane to the midiastinum has been generally accepted. Thus, with time, goiters which have been noted by patients apparently to disappear spontaneously have been subsequently identified in the thorax. As anticipated, the totally intrathoracic goiter, which cannot be felt in the neck, is much rarer than the partially intrathoracic goiter. The Mayo Clinic series[5] included six intrathoracic goiters with no associated palpable cervical component, while Wakeley and Mulvany reported three (which constituted an incidence of 0.23% of all thyroids operated on). A mobile gland that can disappear from the neck or can be caused to pop into view is even rarer. Maland is credited[6] with having initially described the entity and with having coined the name *goitre plongeant*. In 1939 Wakeley[7] reported only two instances of *goitre plongeant* out of his experience with 1300 goiters operated on. In 1949 McCort[4] recorded one such "plunging goiter" among 908 thyroidectomies reviewed at the Massachusetts General Hospital. In 1952 Slobodkin[8] emphasized the infrequency of plunging goiters in his report of an instance. His patient's goiter readily "bobbed" up on straining, and Slobodkin mused that they might better be called bobbing, not plunging, goiters. Roentgenograms of the pationt's chest and neck before and again during positive Valsalva maneuver confirmed the clinical impression that the mass rose out of the thorax.

Our experience with a patient whose intrathoracic goiter was not palpable when the classical maneuver of swallowing with the head slightly flexed forward was employed but which was readily detectable on simple straining seems to be a sufficiently important fundamental nuance in physical diagnosis to be brought to the attention of others. The rareness of *goiter plongeant* per se broadens the indication for publication.

A 56-year-old janitor who had never been aware of a cervical goiter was referred to the hospital by his family physician after a chest roentgenogram disclosed a mediastinal mass (Fig. 1). During the preceding three years exertional dyspnea and cough had been progressing in severity. Hemoptysis had never been noted. Dyspnea was such that after negotiating a single city block the

Submitted for publication Nov. 23, 1956.

From the Department of Surgery, Northwestern University Medical School, and the Surgical Service, VA Research Hospital, Chicago.

Resident Thoracic Surgery, VA Research Hospital, Chicago, now Resident Surgery, Memorial Center, New York (Dr. Shocket); Attending Thoracic Surgeon, VA Research Hospital, Chicago (Dr. Hudson).

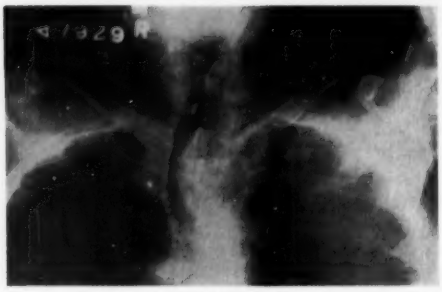


Fig. 1.—Superior mediastinal mass compressing the trachea. Film exposed during full inspiration. Note level of greatest indentation is below the clavicle.

patient found it necessary to stop and catch his breath before resuming. There had never been any associated chest pain. Two pillows were preferred at night, but neither paroxysmal nocturnal dyspnea nor peripheral edema had ever been experienced. The remainder of the history was noncontributory.

A blood pressure of 190/95 was repeatedly verified bilaterally; the pulse was regular and not remarkable. The trachea seemed distorted to the right. On admission examination, no thyroid was palpable on swallowing. This part of the examination was conducted in the classical fashion with the neck slightly flexed in order to relax the sternocleidomastoid muscles. A short moderate systolic murmur and an apparent enlargement of the anterior-posterior diameter of the chest were the only thoracic findings. On inspiration both the liver and the spleen were palpable. Both were nontender. The liver descended about 6 cm. and the spleen 2 cm.

Routine urinalysis, hemoglobin, white blood count, and differential were within normal limits. Tests of liver function were within normal limits, and the cause of the mild hepatosplenomegaly was never ascertained. The suspicion of obstructive pulmonary emphysema was corroborated by vital capacity, which was recorded at 2.7 liters with 48% expired in one second.

To further delineate the superior mediastinal mass, bronchoscopy was undertaken. While the house officer was attempting to pass the scope, the patient strained, somewhat making obvious to the observing attending physician a cervical mass. Subsequent examination disclosed that slight extension of the neck (rather than the customary flexion) with swallowing consistently permitted the mass to rise out of the thorax and to be readily felt in the neck. Also, simple straining, as in the performance of the Valsalva maneuver, even more effectively presented the mass into the

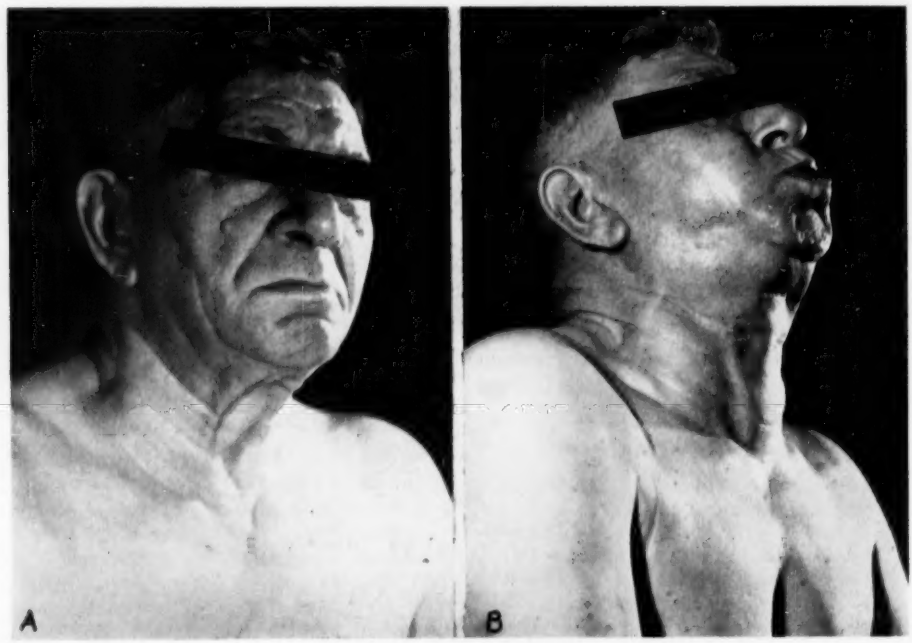


Fig. 2.—*A*, patient at rest. *B*, patient during Valsalva maneuver. Note the mass that rises into the neck.

Fig. 3.—Chest x-ray during Valsalva maneuver. Note indentation of trachea is now well above the clavicle.

neck (Figs. 2 and 3), confirmed the clinical impression, and made the diagnosis reasonably definite. Radioiodine studies confirmed, and subsequent surgery through the usual cervical incision and during endotracheal anesthesia established, the mass to have been pedunculated left lobe of adenomatous goiter.

Comment

Most standard texts of physical diagnosis advise one to obtain relaxation of the sternocleidomastoid by slight flexion of the neck before attempting to feel for thyroid while patient swallows. Werner,[9] however, in his 1955 monograph on the thyroid specifically mentions that occasionally hyperextension instead of flexion may permit a gland to become prominent. Our experience certainly confirms this. In addition, the merit of the Valsalva maneuver clinically and more particularly in conjunction with roentgenography seems to have been somewhat neglected.

So-called plunging goiters are uncommon in the literature. Typically the goiter on slipping into the thorax presses on the trachea sufficiently to embarrass respiration and to produce characteristic frightening choking spells. The patient soon learns that by coughing or otherwise straining he can pop the gland back into the neck and terminate his respiratory and choking discomfort.

Slobodkin's[8] suggestion that it would be more suitable to call these masses bobbing goiters rather than plunging goiters seems most rational to us.

Summary

A case is presented in which an intrathoracic goiter was best demonstrated by Valsalva's maneuver and swallowing with the neck hyperextended. The classical maneuver of swallowing with head flexed was entirely unsatisfactory. The merit of roentgenography in conjunction with the Valsalva maneuver is emphasized. The merit of identifying these goiters as bobbing rather than plunging goiters is endorsed.

55 E. Washington St. (2)

REFERENCES

1. Wakeley, C. P. G., and Mulvany, J. H.: Intrathoracic Goiter, Surg. Gynec. & Obst. 70:702-710, 1940.

2. Wilson, E. F.: Mediastinal Goitre, Brit. J. Surg. 39:120-125, 1951.

3. Lahey, F. H., and Swinton, N. W.: Intrathoracic Goiter, Surg. Gynec. & Obst. 59:627-637, 1934.

4. McCort, J. J.: Intrathoracic Goiter, Radiology 53:227-237, 1949.

5. Ellis, F. H., Jr.; Good, C. A., and Seybold, W. D.: Intrathoracic Goiter, Ann. Surg. 135:79-90, 1952.

6. Clute, H. M., and Lawrence, K. B.: Intrathoracic Goiter, Am. J. Surg. 54:151-160, 1941.

7. Wakeley, C. P. G.: Goitre Plongeant, Clin. J. 68:349-351, 1939.

8. Slobodkin, M.: Goitre Plongeant (Plunging Goiter) Associated with Pharyngo-Esophageal Diverticulum, Radiology 58:378-382, 1952.

9. Werner, S. C.: Physical Examination, in The Thyroid: A Fundamental and Clinical Text, edited by S. C. Werner, New York, Paul B. Hoeber, Inc. (Medical department of Harper & Brothers), 1955, pp. 265-272.

Stensen's Duct: Key to Parotidectomy

ALEX W. ULIN, M.D.; EDWARD W. EHRLICH, M.D., and J. WINSLOW SMITH, M.D., Philadelphia

Surgery of the parotid gland demands an exacting knowledge of the anatomy of the facial nerve. Its relation to the parotid has only recently been presented by Bailey (1941),[1] McCormack (1947),[2] and Davis (1956).[3] Most surgeons encounter the problem of parotidectomy infrequently. Resort to standard references presents a sterotyped technique for the operation. Review of the literature, on the other hand, may be confusing because of the many surgical approaches to the facial nerve which have been described. The purpose of this paper is twofold: (1) to relate our antomical and clinical experience with the use of Stensen's duct to gain access to the facial nerve branches and gland and (2) to present a compendium of surgical techniques for parotidectomy which would be useful to the surgeon in selecting an indicated approach.

Submitted for publication Nov. 28, 1956.

From the Department of Surgery, Hahnemann Medical College and Hospital of Philadelphia.

Method

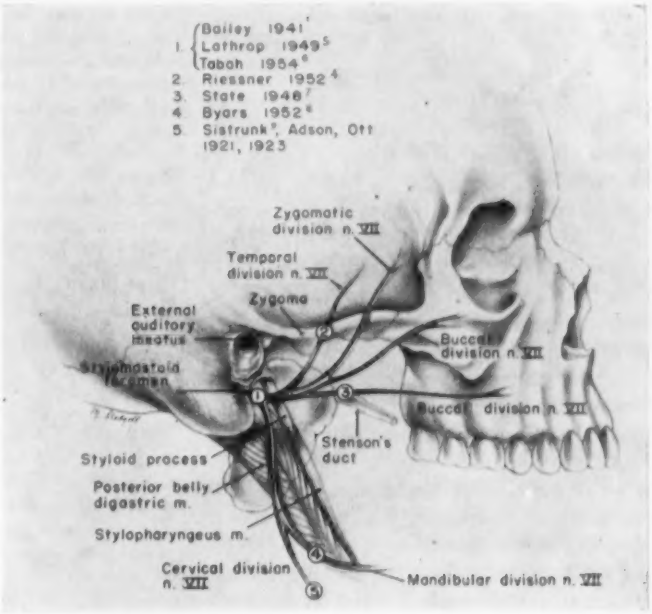
Thirty cervicofacial halves of premature and stillborn infants, anatomical specimens selected from material available in the Department of Anatomy, Hahnemann Medical College, were dissected according to techniques of parotidectomy described by various authors (Table, Fig.). General principles in every case included attention to the following: exposure of the entire gland and duct by development of adequate and liberal skin flaps, as advocated by Brown[11]; complete dissection of the superficial lobe of the parotid from the underlying branches of the facial nerve without handling the nerve itself, and a complete anatomic demonstration of the main trunk of the nerve with its various branches in continuity.

Observations

Since this study was an investigation in surgical anatomy, functional results were not

Compendium of Techniques for Parotidectomy

		Landmarks	Comment
1. Blatrunk,[9] Adson[10]	1921 1932	Inframandibular branch of the facial nerve as a guide to retrograde dissection	Generally difficult to identify and to utilize smaller branches as a guide
2. Bailey[1]	1941	Direct exposure of the main trunk of the facial nerve as it exits from the stylomastoid foramen with external carotid artery ligation	Excellent method for peripherally placed tumor; usually difficult for large tumor overlying and obscuring the angle of the mandible; hemostasis assured with carotid artery ligation
3. State[7]	1948	Commences dissection from the anterior edge of the parotid; uses duct as a tractor with early identification of the buccal branch of the facial nerve	Excellent for general dissection; buccal branch is the largest peripheral branch of the facial nerve
4. Lathrop[4]	1949	Direct exposure of the main trunk of the facial nerve as it lies on the lateral surface of the styloid process; dissects the posterior border of the gland from the external auditory canal following the canal down to the bony skull	Excellent direction for dissection afforded by cartilaginous canal; may be confusing in about 30% of persons where styloid process is absent[5]
5. Byars[6]	1952	Locates lower division of the facial nerve in relation to the posterior facial vein as the vein appears below the lower border of the superficial lobe of the gland	One of the few relatively constant peripheral veins; the nerve branches involved are usually extremely fine
6. Riessner[8]	1952	Exposure of upper edge of gland with identification of the zygomatic branch of the facial nerve as it crosses the zygomatic arch	The glandular structure is thickest superiorly, and the nerve branches are relatively large; exposure is difficult with the usual hockey-stick incision, and inverted L-shaped incision is necessary; this incision gives poor exposure of the gland generally
7. Tabah[9]	1954	Exposure of the main trunk of the facial nerve above the posterior belly of the digastric muscle	Excellent method for peripherally placed tumor; usually difficult for large tumor overlying and obscuring the angle of the mandible



Semidiagrammatic representation of anatomic landmarks necessary for orientation in order to expose the facial nerve according to various techniques of parotidectomy (Table).

possible. Our purpose was to demonstrate to our own satisfaction the ease of dissection of the gland from the nerve with use of one or another technique with special emphasis on the use of Stensen's duct as a "dissecting handle."

We found the parotid gland to be a bilobate gland; the glandular tissue is arranged in such a fashion around the ramus of the mandible that there is a superficial and deep lobe. The connecting bridge of tissue between the deep and superficial lobe has been called the isthmus. Further, a definite cleavage plane exists between the masseteric surface of the superficial lobe and the masseter muscle. The facial nerve lies in this plane. We found it feasible in all our cases, starting to dissect anteriorly, to peel the gland from the nerve, to transect the isthmus, and, continuing dorsalward, to expose the base of the pes anserinus. These findings are in agreement with the reports of others. McCormack[2] has demonstrated at least six patterns of ramification of the divisions of the facial nerve, four general configurations of the superficial lobe, and three general modes of origin and course of Stensen's duct. Davis and Anson[3] and others[1,2,7] have emphasized the bilobate character of the parotid and the relationship of the pes anserinus of the facial nerve to the isthmus of the parotid gland. These workers have shown the presence of a constant isthmus connecting the superficial and deep lobes, around which the facial nerve arborizes into its five terminal divisions.

With all the anatomic variations in this area, we believe that the structures are found constantly at only two points, namely, (1) the facial nerve deep in the neck which exits from the stylomastoid foramen and runs for a short course as a single trunk anterior and deep to the mastoid process and (2) the point at which Stensen's duct curves around the anterior edge of the masseter muscle to pierce the buccinator and enter the mouth. Logical surgical attack of a parotid tumor by superficial lobectomy with preservation of the facial nerve would then be directed toward identification and exposure of the nerve or the duct at either of these points.

Identification of the parotid duct is usually relatively easy. Its diameter in the adult

averages 3 mm. An additional technical aid, suggested by one of us (J. W. S.), proved quite helpful in its identification; the duct may be probed intraorally with a lacrimal duct probe. This is simple to perform in infants. The orifice is well marked, and the duct follows a short, straight course. Identification of the parotid duct serves several useful purposes: (1) The buccal branch of the facial nerve, the largest peripheral division, is in regular relationship to Stensen's duct, either embracing it, overlying its lateral aspect at some point in its extraglandular course, or lying deep to it; (2) it marks the anterior edge of the parotid, and (3) traction on Stensen's duct helps to direct the dissection along the cleavage plane between the parotid gland, the nerve, and the underlying masseter muscle. In about one-half of our specimens the parotid duct was of less help in these respects because of variation in mode of origin and course; the resort then was to one or another method of dissection as tabulated.

Report of Cases

Case 1.—A 53-year-old white man was admitted to Hahnemann Hospital on Feb. 13, 1950, because of a tumor of the right parotid gland. The tumor had been present for 10 years, asymptomatic, but recently had enlarged somewhat. The examination of the right side of the jaw revealed a mass, approximately 4 cm. in diameter, overlying the parotid gland and the mandibular angle. The mass was rounded, somewhat irregular, nontender, and freely movable. There was no adenopathy in the cervical region or any evidence of spread of this tumor mass. At operation a No. 2 lacrimal duct probe was successfully introduced into Stensen's duct and fixed to the opposite cheek. Incision was made in a linear fashion from the temporal portion anterior to the auricle, extending down along the crease of the neck, below the mandible. Skin flaps were developed anteriorly up to the parotid duct, which was palpated with ease, and posteriorly over the posterior edge of the sternocleidomastoid muscle. Identification of Stensen's duct allowed early identification of the buccal branch of the facial nerve, thereby facilitating dissection of the superficial lobe of the parotid with contained tumor. Pathologic report: mixed tumor.

Case 2.—A 32-year-old Negro woman was admitted to Hahnemann Hospital on July 20, 1955, with a freely movable, 1.5 cm. mass anterior to the left ear overlying the mandibular angle. There was a history of progressive enlargement of this mass during the eight months prior to admission. At operation a J-shaped preauricular incision was made with reflexion of a large skin flap demonstrating the entire superficial lobe of the parotid. Stensen's duct was isolated, doubly ligated, divided between the ligatures, and reflected posteriorly. Traction on Stensen's duct delineated the anterior edge of the parotid and branches of the facial nerve. Dissection was carried dorsally, peeling the superficial lobe of the parotid from the facial nerve underlying it. The patient developed a postoperative salivary fistula which responded readily to x-ray therapy. Pathologic report: lymph adenoma.

Case 3.—A 39-year old white woman was admitted to Hahnemann Hospital Jan. 8, 1956, with a 3 cm. ovoid mass overlying the right mandibular angle, which had been present for approximately five years prior to admission. The mass was slightly mobile, and smoothly rounded. At operation the superficial lobe of the parotid was exposed, utilizing a long preauricular J-shaped incision. Stensen's duct was identified, double ligated, divided between the ligatures, and reflected posteriorly. Traction on Stensen's duct demonstrated the anterior edge of the parotid gland, the buccal branch of the facial nerve, and the mandibular branch of the facial nerve. By blunt dissection on the surfaces of these nerves, the anterior two-thirds of the parotid gland with the contained tumor was dissected free of these nerves. This patient developed paresis of the muscles of the angle of the mouth, which disappeared seven months after the operation. Pathologic report: mixed tumor.

Comment

Several technical points became obvious early in this study.

1. Exposure: The entire gland must be visualized. This entails the development of skin flaps to demonstrate the zygoma, the anterior edge of the masseter, the mastoid process, and the anterior edge of the sternocleidomastoid muscle. This may be accomplished by several types of incisions. The prototype is the hockey-stick incision with its vertical component beginning just at the zygoma, continued caudally preauricularly to the angle of the jaw, with a horizontal component below the body of the mandible. We wish to emphasize that this horizontal component below the mandibular edge be generous, so that a liberal skin flap

is raised. With this exposure Stensen's duct is quickly and easily identified. The buccal branch of the facial nerve is also quickly identified because of its regular relationship to Stensen's duct in this region. The lower portion of this wound allows access to the external carotid artery for ligation if necessary. With these two structures secured at the anterior edge of the parotid early in the operation, the surgeon may confidently carry his dissection posteriorly.

2. The gland may be bluntly dissected from the nerve. Using a fine, curved (Crile) hemostat, one is able to separate the gland from the nerve by inserting the points of the instrument into the glandular structure on the surface of the nerve branch; spreading the points easily dislodges the gland from the nerve without distorting the nerve itself.

3. Hemostasis must be accurate to avoid tissue staining. The speciments used were not embalmed, and it was evident that, even with venous back bleeding, tissue was soon stained unrecognizably. This difficulty may be overcome in cases where a hemostatic problem is anticipated by external carotid artery ligation, as suggested by Bailey,[1] or by the use of hypotensive anesthesia in suitable cases, as suggested by Fitzgibbon.[12] State [7] recommends a saline-epinephrine injection, given into the cleavage plane between the parotid and the underlying masseter, to aid further dissection and hemostasis. A suction apparatus equipped with a Frazer tip aids immeasurably in fine dissection.

The obvious deterrent to extensive parotid surgery is fear of injuring the facial nerve in the course of dissection. Perzik [13] has shown, however, that morbidity in parotid gland surgery of more magnitude than simple enucleation is 100%. The surgeon and the patient should be willing to accept more or less temporary deformity of facial musculature as the price of a complete operation. Paresis of the muscles of facial expression occurred in all of Perzik's cases whenever the facial nerve was exposed; the duration, which varied from one day to one year in the absence of its transection, was directly related to the magnitude of resection attemped. Interestingly, there was no manipulation of the nerve with nerve hooks, electrostimulator, or hemostats.

Opinions on the extent of surgery required for cure of the mixed tumor of the parotid vary from simple enucleation to total parotidectomy. The array of suggested techniques is likewise confusing; however, the aim of parotid surgery is the removal of all or part of the gland and the tumor, leaving the facial nerve intact. In the case of small tumors, it is usually possible to excise the tumor and a sufficient margin of normal tissue surrounding the tumor without exposing the facial nerve itself. Where the tumor achieves great size, the main trunk of the facial nerve becomes inaccessible, because the tumor usually overlies it.

That so many techniques for parotidectomy have been advocated is not surprising when one considers the great anatomic variation which occurs in this region and the natural history of the mixed tumor. The mixed tumor usually occupies or arises from the lower two-thirds or one-half of the superficial lobe of the parotid. It may achieve great size, either by intermittent or slow steady growth or by cystic and hemorrhagic change. The average duration of the tumor was 13 years in Ward and Hendrick's [14] series. With the knowledge of the average location of the tumor, that is, that the tumor usually occupies the area of the parotid immediately covering the main trunk of the facial, a technique which starts dissection away from the tumor and its blood supply is of value, especially where delicate nerve structures must be identified and preserved. We believe, when applicable, such a technique utilizes Stensen's duct as the key to the dissection. If not applicable because of anatomic variation, distortion of the gland by tumor, or tissue staining by bleeding, resort to the other techniques listed in the compendium (Table), singly or in combination, is necessary.

Summary

Thirty cervicofacial halves of infants have been dissected to test the technical ease of parotidectomy according to several authors.

Technical considerations of parotidectomy are considered with pertinent case reports.

An additional approach to parotidectomy which utilizes Stensen's duct is described and discussed.

Hahnemann Medical College and Hospital of Philadelphia, 230 N. Broad St. (2): Dr. Ulin

REFERENCES

1. Bailey, H.: Surgical Anatomy of the Parotid Gland, Brit. M. J. 2:245 (July 31) 1948.

2. McCormack, L. J.; Cauldwell, E. W., and Anson, B. J.: Surgical Anatomy of the Facial Nerve with Special Reference to the Parotid Gland, Surg. Gynec. & Obst. 80:620 (June) 1945.

3. Davis, R. A.; Anson, B. J.; Budinger, J. M., and Kurth, L. E.: Surgical Anatomy of the Facial Nerve and Parotid Gland Based upon a Study of 350 Cervicofacial Halves, Surg. Gynec. & Obst. 102:385 (April) 1956.

4. Riessner, D.: Surgical Procedure in Tumors of Parotid Gland, A. M. A. Arch. Surg. 65:831 (Dec.) 1952.

5. Lathrop, F. D.: Technic of Exposing the Facial Nerve as an Aid to Surgery of the Parotid Gland, S. Clin. North America 29:673 (June) 1949.

6. Tabah, E. J.: Surgical Management of Parotid Tumors, Canad. M. A. J. 71:456 (Nov.) 1954.

7. State, D.: Superficial Lobectomy and Total Parotidectomy with Preservation of the Facial Nerve in the Treatment of Parotid Tumors, Surg. Gynec. & Obst. 89:237 (Aug.) 1949.

8. Byars, L. T.: Preservation of the Facial Nerve in Operations for Benign Conditions of the Parotid Area, Ann. Surg. 136:412 (Sept.) 1952.

9. Sistrunk, W. E.: Tumor of the Parotid Gland, S. Clin. North America 1:1515 (Oct.) 1921.

10. Adson, A. W., and Ott, W. D.: Preservation of the Facial Nerve in the Radical Treatment of Parotid Tumors, Arch. Surg. 6:739 (May) 1923.

11. Brown, J. B., and Fryer, M. P.: Tumors in the Parotid Region, Am. Surgeon 18:880 (Sept.) 1952.

12. Fitzgibbon, G. M.: Discussion on the Surgical Treatment of Parotid Tumors, Proc. Roy. Soc. Med. 46:1017 (Dec.) 1953.

13. Perzik, S. L.: Facial Nerve Paresis in Parotid Surgery, Surgery 36:751 (Oct.) 1954.

14. Ward, G. E., and Hendrick, J. W.: Diagnosis and Treatment of Tumors of the Head and Neck, Baltimore, Williams & Wilkins Company, 1950.

Congenital Cystic Dilatation of the Common Duct (Choledochal Cyst)

Report of Two Cases

LUTHER M. KEITH Jr., M.D., Columbus, Ohio; JEROME M. RINI, M.D., Portsmouth, Ohio, and L. HAROLD MARTIN, M.D., Ashland, Ohio

Congenital cystic dilatation of the common bile duct is a rare anomaly but it may simulate usual types of acute or chronic biliary disease in the adult. The general surgeon, unexpectedly confronted with this lesion at the time of anticipated elective cholecystectomy, might have difficulty both in recognizing this anomaly and in selecting the surgical procedure of choice. Attempting to excise the cyst is both dangerous and unjustified, since excellent results are achieved by cystoduodenostomy. For these reasons, two recent and unusual cases treated at this clinic seem worthy of presentation. To our knowledge, this condition occurred in the oldest patient yet reported.

Report of Cases

CASE 1.—A 43-year-old white woman initially entered this hospital in February, 1955, complaining of recurrent episodes of right subcostal pain. She dated her symptoms back to 18 months prior to admission, when she noted the onset of recurrent attacks of right upper quadrant pain, usually initiated by eating, and radiating most frequently to the left but occasionally to the right scapular area. These episodes were often attributed to greasy or fried foods and on occasion were accompanied by nausea and vomiting. In addition, she usually experienced epigastric fullness and eructations even in the absence of pain. During some of the acute attacks, her urine became dark and her stools light in color, although she disclaimed recent jaundice.

Submitted for publication Oct. 11, 1956.

From the Department of Surgery and the Surgical Service, University Hospital, Ohio State University; Clinical Fellow, American Cancer Society (Dr. Rini).

She had a single episode of similar pain followed by jaundice of two weeks' duration at the age of 18 but was not examined or treated.

The only significant physical finding was slight tenderness in the right subcostal area. She was not jaundiced and had no palpable abdominal mass.

Admission blood count, hemoglobin, and urinalysis were within normal limits. Blood urea nitrogen, serum amylase, and prothrombin time were reported as normal. Two preoperative cholecystograms utilizing iopanoic acid (Telepaque) failed to visualize the gallbladder, and an upper gastrointestinal barium study was within normal limits.

The preoperative diagnosis was chronic cholecystitis and cholelithiasis and probable choledocholithiasis. At operation, the gallbladder was found to be thickened and to contain many small palpable stones. The hepatoduodenal ligament at the edge of the foramen of Winslow was found to be unusually thick and contained a firm cystic mass. Further dissection and exploration identified this lesion as a 5×7 cm. cystic dilatation of the supraduodenal segment of the common duct extending up to the hepatic ducts. The cystic duct arose from the superior lateral aspect of the cyst, 1.5 cm. below the right hepatic duct. The cyst was aspirated with a 20-guage needle, and dark, tenacious bile was obtained.

An uneventful cholecystectomy was performed. The common duct cyst was opened for exploration by a 2 cm. vertical incision placed in the lower, anterior surface just above the superior margin of the duodenum. This incision resulted in forceful flow of 80 cc. of dark bile under considerable pressure. On exploration and irrigation of the cyst, three small pigmented stones were recovered with considerable muddy sediment which had settled in the dependent portion.

Scoops and bougies could be easily passed into each hepatic duct but not into the duodenum. After enlargement of the choledochostomy, a minute slit-like opening could be seen at the bottom of the cyst. This would admit only a 7 F.

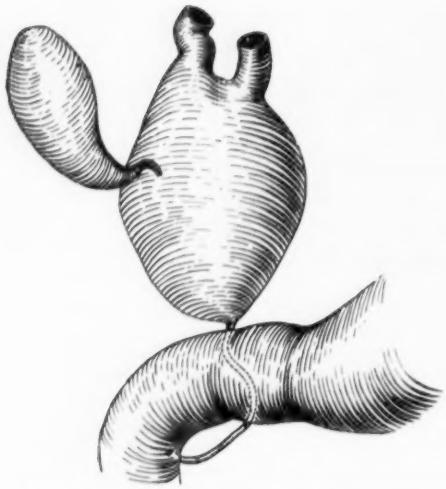


Fig. 1.—Schematic drawing of a choledochal cyst extending up to the hepatic ducts. Note the stenotic postcystic portion of the common duct.

ureteral catheter, which could be passed into the duodenum, demonstrating the marked stenosis of the distal, postcystic segment of the common duct (Fig. 1). An operative cholangiogram was obtained which substantiated the operative diagnosis.

The choledochostomy site was utilized, after mobilizing the duodenum by a Kocher maneuver, for a mucosa-to-mucosa cystoduodenostomy by two layers of interrupted fine silk. A size 16 F. catheter was left in the cyst through the cystic duct for drainage and subsequent cholangiography.

The patient's postoperative course was uneventful. A repeat cholangiogram on the 10th postoperative day demonstrated free flow of contrast medium through the anastomosis and rapid decrease in the size of the cyst (Fig. 2). She was discharged on the 12th postoperative day. Since operation, the patient has gained weight, has returned to work, and complains only of occasional postprandial fullness. An intravenous cholangiogram nine months postoperatively demonstrated continued shrinkage in the size of the cyst and a patent anastomosis.

Case 2.—A 41-year-old white housewife entered University Hospital on May 8, 1956, complaining of "gallbladder trouble" of two years' duration. She was well until two years before admission, when her initial episode of severe epigastric pain, nausea, and vomiting occurred. This resulted in four days' hospitalization for suspected cholecystitis, for which she received supportive and symptomatic treatment. Sixteen months later, she noted the onset of postprandial epigastric discomfort and occasional nausea and vomiting in response to fatty food ingestion. Since then she had lost 20 lb. of weight. Twelve days prior to this admission the patient developed acute unrelenting epigastric pain radiating to the right subscapular area which was accompanied by fever, leukocytosis, and right upper quadrant tenderness. She disclaimed ever having jaundice, acholic stools, or dark urine. Acute cholecystitis was suspected, and she was admitted to another hospital, where cholecystectomy was recommended. At operation, a cystic mass was found in the region of the common bile duct, which was left undisturbed. A cholecystostomy and biopsy of the gallbladder were also performed. The biopsy was reported as showing acute and chronic cholecystitis. Two subsequent cholangiograms utilizing the cholecystostomy tube demonstrated a cystic dilatation of the com-

Fig. 2 (Case 1).—Postoperative cholangiogram. The stenotic distal common duct and the functioning choledochoduodenostomy are readily visible.

Fig. 3 (Case 2).—Cholangiogram following cholecystostomy. The narrowed common duct below the cyst is demonstrated. Note also reflux into the pancreatic duct.

mon and common hepatic ducts. She was then transferred to University Hospital for definitive operation.

On admission here, the patient was a thin white female without symptoms. Her temperature, pulse rate, blood pressure and various pertinent laboratory studies were normal. Positive physical findings were limited to the abdomen where there was a recent, healing right upper quadrant paramedian incision and a cholecystostomy tube still in place.

A repeat cholangiogram confirmed the presence of congenital cystic dilatation of the common and common hepatic ducts with a configuration similar to that in the first case (Fig. 3).

At operation, on May 11, 1953, cholecystectomy and cystoduodenostomy were performed. The gallbladder showed papillary hyperplasia and cholesterolosis. The patient had an uneventful postoperative course.

Comment

The cases described are unusual in that the diagnosis was not established until the ages of 41 and 43 and there was no palpable mass or recent jaundice in either case. In addition, both patients had concomitant gallbladder disease which may have been partially responsible for their symptoms. Most reported cases have presented a diagnostic triad of abdominal pain, tumor, and jaundice. The etiology of this lesion is controversial, but the two factors of congenital weakness of the common duct wall and distal choledochal obstruction producing increased proximal intraductal pressure are thought to be significant. The mechanism is probably analogous to that of achalasia of the esophagus or megacolon with rectosigmoid stenosis.

Excellent discussions and reviews of this interesting lesion have been published by Gross [1] and by Attar and Obeid.[2]

The most widely accepted procedure is cystoduodenostomy, although choledochojejunostomy utilizing a Roux-Y antiperistaltic segment has been satisfactory. Ill-advised excision of the cyst produces a biliary defect difficult to repair in that both hepatic ducts would be divided and require separate anastomosis to small bowel. In general, good results achieved with cystoduodenostomy indicate it as the procedure of choice.

These cases have been reported to call the attention of the surgeon again to this unusual anomaly and to emphasize the necessity for a sound decision at the time of operation. It is suggested that operative cholangiography is a valuable diagnostic aid in this lesion as it is in other more common types of biliary disease.

REFERENCES

1. Gross, R. E.: Idiopathic Dilatation of the Common Bile Duct, in Surgery of Infancy and Childhood, Philadelphia and London, W. B. Saunders Company, 1953, p. 524.

2. Attar, S., and Obeid, S.: Congenital Cyst of the Common Bile Duct: A Review of the Literature and a Report of 2 Cases, Ann. Surg. 142: 289, 1955.

Congenital Abnormal Rotation of the Intestines

JOSEPH R. WILDER, M.D., New York

Anatomists recognized and described congenital abnormal intestinal rotations more than 100 years ago.[1] The significance of this maldevelopment from a clinical viewpoint was not fully appreciated until a little more than 30 years ago.[1-3]

In the past two decades increasing experience with congenital abnormal rotation of the intestines and related incomplete peritoneal fixation has resulted in well-established and precisely defined clinical syndromes.[2-9]

The embryology of this abnormality has been well described.[2,3,6,8,10] Some difference in opinion exists, referable to the exact mechanics of midgut rotation. There is, however, complete agreement concerning the pathology, diagnosis, and management of the resultant clinical entities.

Failure of proper rotation and related peritoneal fixation is believed to occur during the first 5 to 12 weeks of gestation. The midgut, growing faster than the surrounding celomic cavity, projects into the umbilical cord. As development continues, the peritoneal cavity increases in size, with the midgut withdrawing back into the abdomen, rotating on itself in counterclockwise fashion. Equally important is the fusion of the mesentery of the small intestine to the posterior abdominal wall and of the mesentery of the cecum, ascending and descending colon to the posterior peritoneum. Accordingly, the various abnormalities which may occur—omphalocele malrotation, volvulus, internal herniae, and mobile cecum—are seen to result from (1) abnormal congenital rotation of the intestines and (2) failure of the peritoneal attachments and mesentery to fuse in normal fashion.

Recorded for publication Jan. 15, 1957.

Numerous reports have appeared in the literature, emphasizing the importance of recognizing the respective clinical patterns produced by the above malformations.[1-21] From a practical viewpoint the signs and symptoms (save for omphalocele—immediately diagnosed) are those produced by acute duodenal obstruction and/or intestinal obstruction. Duodenal obstruction is secondary to abnormal midgut rotation, which results in peritoneal bands stretching across the second or third portions of the duodenum or from external duodenal pressure caused by a malpositioned cecum. Intestinal obstruction occurs secondary to volvulus or internal herniae. The majority of these cases produce symptomology shortly after birth and in the pediatric group; however, adults have been reported.[11] I recently operated on a 75-year-old man with classical high duodenal obstruction and a 180-degree volvulus resulting from malrotation and failure of fusion of the mesentery and peritoneum.

The clinical picture will obviously vary, depending on the degree and severity of the obstruction, either duodenal or intestinal, and associated complications—malnutrition, electrolyte imbalance, gangrene of the intestines, et cetera. The pertinent consideration is to include abnormalities of congenital rotation of the intestine in the diagnostic armamentarium for obstructive lesions in the gastrointestinal tract, especially in infants and children. This likewise applies to the surgeon who must be prepared to recognize and properly manage these lesions when encountered in the operating room—frequently in unexpected circumstances. In some instances multiple pathologies will occur. For example, volvulus of the small intestine and partial duodenal obstruction frequently coexist in the same

patient. The dangers inherent in correcting one lesion and missing the other are self-evident.

In both acute and chronic cases careful history and physical examination, along with selective x-ray studies of the gastrointestinal tract, will facilitate diagnoses of the various clinical syndromes resulting from abnormal rotation of the intestines.

There is a tendency in chronic cases to suspect patients of celiac disease, cyclic vomiting, malnutrition, gastrointestinal allergy, and, last but not least, functional disease.

The following case of abnormal rotation of the intestines is presented to further emphasize the pattern that chronic cases may follow and to reveal some of the shortcomings in treating patients as "functional" problems or "psychoneurotics" without thorough study and attention.

A 5-year-old well-developed and well-nourished white child was admitted for diagnostic evaluation of intermittent vomiting since birth.

Family history was unremarkable. The parents were in excellent health, as was an older brother, aged 9.

Present Illness.—For the first four and one-half years of life this youngster had intermittent episodes of vomiting, averaging one to two times per month. The contents were always gastric and contained no blood. There was never associated anorexia, intolerance to foods of any kind, weakness, weight loss, change in bowel habits, chills or fever, or noticeable discomfort, save for mild distress just before and during emesis. Abdominal distention was never in evidence. The child engaged in normal activities prior to and immediately after the vomiting episodes. The parents had no way of predicting when these attacks would occur. There was no pattern—no particular relationship to meals, time of the day, or specific activity. Two years prior to admission the parents observed temper tantrums associated with the vomiting episodes. However, questioning revealed many temper outbursts without vomiting.

Numerous physical examinations were all reported as negative. Physical development was normal. The boy was considered a bright and active child. After many trials, involving dietary changes, play activity changes, and disciplinary action, the parents were told that the vomiting was on an emotional basis. X-rays of the gastrointestinal tract were never performed.

Six months before admission the vomiting became more frequent, one to two times per week, never incapacitating and never necessitating restriction or limitation of activities. The parents found it increasingly difficult to cope with the problem, placing full blame for the child's attacks on their own short comings. This was made more

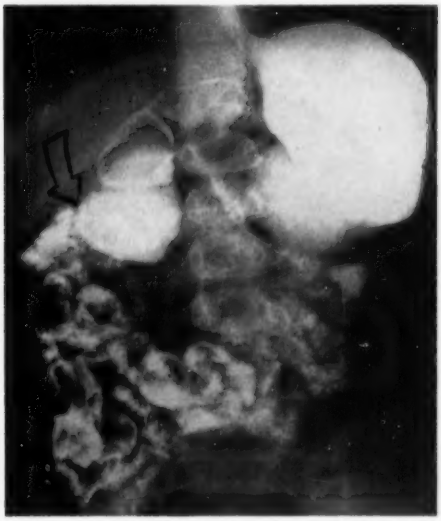


Fig. 1.—Preoperative gastrointestinal series. Arrow pointing to site of duodenal obstruction.

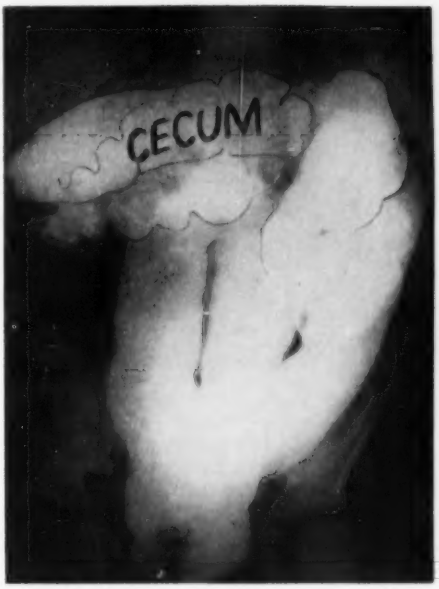


Fig. 2.—Preoperative barium enema. Observe cecum riding high in the epigastrium.

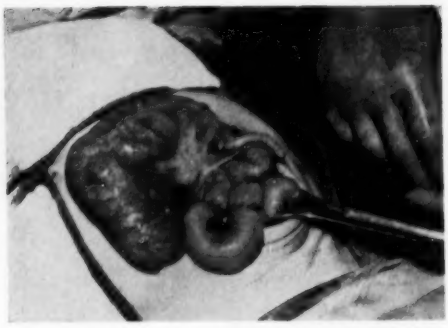


Fig. 3.—Abnormal mobile colon with cecum and appendix in left upper quadrant.

Fig. 4.—Forceps pointing to obstructive bands. Notice proximal dilatation of duodenum.

difficult by virtue of their older child being "completely normal." This served to further confuse the father and mother, as they tried to understand their inadequacies in raising their second child.

Physical examination at the time of admission was negative. One noted an attractive, well-developed, well-nourished, intelligent youngster. The abdomen was scaphoid. There was no tenderness, no masses, and peristalsis was normal.

Laboratory Studies.—Complete blood count, urinalysis, blood sugar, and liver indices were normal. A barium enema and gastrointestinal series established the diagnosis of congenital abnormal rotation of the intestines with partial high duodenal obstruction (Figs. 1 and 2).

Course in the Hospital.—On the eighth hospital day exploration was carried out through a left infracostal transverse incision. (Figure 3 shows the mobile cecum, as encountered at surgery, located in the upper abdomen.) Mesenteric and peritoneal attachments were incomplete; the omentum was filmy and undeveloped. One could sweep the entire small intestines and the right, transverse, and descending colon on the abdominal wall. There was no evidence of volvulus. Careful examination revealed characteristic bands overlying the second portion of the duodenum with proximal dilatation secondary to the obstructing bands (Figs. 4 and 5). These bands were divided, relieving the obstruction.

A prophylactic appendectomy was performed. The postoperative course was uneventful, and the child was discharged on the seventh postoperative day.

One month after surgery a gastrointestinal series was obtained (Fig. 6). There was no evidence of obstruction. One noticed the entire duodenum on the left side of the midline.

When seen in follow-up examination three and six months later, the child was in excellent health. The parents enthusiastically proclaimed their amazement and delight at the personality change in their child. He was in their minds "a normal child."

Fig. 5.—Black silk ligatures have been placed about the obstructing bands.

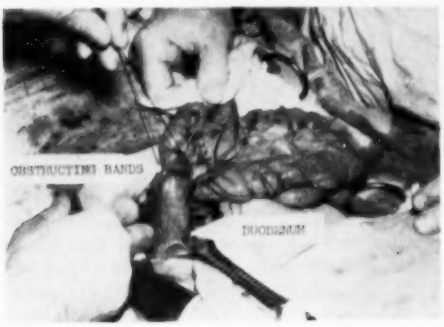


Fig. 6.—Postoperative gastrointestinal series. Notice transverse duodenum to the left of the midline.

Summary

The literature and salient features regarding congenital abnormal rotation of the intestines with the various clinical entities are discussed. A characteristic case with partial high duodenal obstruction is presented, emphasizing the importance of thorough study in youngsters with chronic gastrointestinal complaints.

New York Medical College, 1249 Fifth Ave. (29)

REFERENCES

1. Dott, N. M.: Anomalies of Intestinal Rotation: Their Embryological and Surgical Aspects with Report of Five Cases, Brit. J. Surg.
2. Danelius, G.: Abnormalities of the Rotation of the Midgut, Am. J. Digest. Dis. 4:231-236 (June) 1937.
3. Donaldson, H. H.: Abnormalities of Rotation of the Midgut, Am. J. Surg. 32:352-356 (May) 1936.
4. Dixon, C. F., and Deuterman, J. L.: Malrotation of the Intestine, Proc. Staff Meet. Mayo Clin. 11:140-142 (Feb. 26) 1936.
5. Dobbs, R. H., and Heritage K.: Malrotation of the Intestines in a Child Aged 9 Months Cured by Operation, Proc. Roy. Soc. Med. 30:404-405 (Feb.) 1937.
6. Gardner, C. E., Jr.: Surgical Significance of Anomalies of Intestinal Rotation, Ann. Surg. 131: 879-898 (June) 1950.
7. Gripenberg, L.: On the Anomalies of Intestinal Rotation, Acta chir. scandinav. 104:261-284, 1952.
8. Nelson, W.: Embryology of the Midgut and Its Relationship to Midgut Anomalies, Am. Surgeon 18:579-585 (June) 1952.
9. Pollock, L. H.: Malrotation of the Intestine, J. Mt. Sinai Hosp. 17:886-906 (March-April) 1951.
10. Gross, R. E.: Surgery of Infancy and Childhood, Philadelphia, W. B. Saunders Company, 1953.
11. Brown, R. B., and Ross, D.: Congenital Abnormalities of Intestinal Rotation and Mesenteric Attachment—A Cause of Intestinal Obstruction in the Adult, Ann. Surg. 134:88-98 (July) 1951.
12. Case, T. C.: Malrotation of the Colon, New York J. Med. 50:1497-1498 (June 15) 1950.
13. Madding, G. F.; Everhart, M. W., and Heath, J.: Congenital Duodenal Atresia with Malrotation of the Intestine: A Case Successfully Treated by Duodeno-Jejunostomy, Ann. Surg. 131:433-436 (March) 1950.
14. Miller, E. M.: Malrotation of the Colon, editorial, Surg. Gynec. & Obst. 87:235-237 (Aug.) 1948.
15. Nordland, M.: Congenital Shortening of the Small Bowel with an Anomaly of Rotation, Minnesota Med. 22:567-568 (Aug.) 1939.
16. Rosenblatt, M. S.: Faulty Rotation of the Intestines, Northwest Med. 36:425-427 (Dec.) 1937.
17. Rubin, E. L.: Radiological Aspects of Anomalies of Intestinal Rotation, Lancet 2:1222-1226 (Nov. 30) 1935.
18. Sager, W. W., and Solnitzky, O.: Anomalies of the Intestine: A New Operative Approach, Am. J. Surg. 27:126-134 (Jan.) 1935.
19. Susnow, D. A.: Left-Sided Colon, Am. J. Surg. 79:129-136 (Jan.) 1950.
20. Swenson, O., and Fisher, J. H.: Malformations of the Colon, S. Clin. North America 35: 1239-1243 (Oct.) 1955.
21. Zimmerman, L. M., and Laufman, H.: Intra-Abdominal Hernias Due to Developmental and Rotational Anomalies, Ann. Surg. 138:82-91 (July) 1953.

Editorials

Seat Belts and Abdominal Injury

In regard to the significant and interesting case report, entitled "Intra-Abdominal Injury from Safety Belt in Auto Accident" by Jacob Kulowski and William B. Rost, in the December, 1956, issue of the ARCHIVES, we have the following comments.

Except for the unfortunate title, we concur in the report in its reportorial aspects, of course; but with the "Comment" we cannot concur. The two possibilities are obvious: "The primary injury could have been caused either by contusion through pressure from the belt or the belt buckle, or inertial localized hemorrhage and subsequent inflammatory reaction of the mesenteric peritoneum." In our opinion, the second explanation seems the more likely, for the following reasons:

1. There was no evidence of severe snubbing action of the belt. For snubbing action of the belt to have produced the reported injury, one would expect to have abrasions, bruises, or ecchymoses in the region of the greater trochanters, the anterior superior spines of the ilium, or the abdominal wall. We are aware that small blunt, rounded objects may produce injury to abdominal viscera without evidence of external violence, but the mechanism is quite different from that of the belt which is stretched tautly across the lower torso.

2. Snubbing action of the belt, we think, would have injured the bowel proper rather than the mesentery and would have produced a broader, more widespread injury. In the reported injury, the bowel proper was apparently not injured at all, and the site was a well-localized injury in the mesentery.

3. The injury seems to us more likely to have been "inertial localized hemorrhage and subsequent inflammatory reaction of the mesenteric peritoneum." The presence of the hearty meal would fortify this impression.

4. We know of many crash injuries in which snubbing action of the belt was severe—in fact, in some 200 or more, the belts were broken—and yet the incidence of abdominal injury was less than 1%. We know of many others in which there was no evidence of snubbing of the belts and in which the abdominal injuries were clearly inertial.

5. The efficacy of the seat belt in decelerative situations is so good because it restrains the body at its strongest and most flexible point, the hip joint region. And yet we know of many instances in which the belt has been jerked upward by attached shoulder straps, with resultant compression fractures of the spine because of crash forces upward through the seat, in which no abdominal injury occurred. In fact, the incidence of abdominal injury is almost nil in these cases. This is not to deny that every precaution should be taken to wear the belt low. Installation should be such as to favor the engagement of the belt at impact with that area below the anterior spines of the ilium.

Submitted for publication Jan. 17, 1957.

6. A survey requested by one of the large motorcar manufacturers resulted in the opinion by obstetric specialists that seat belts should be worn by women in all stages of pregnancy. Such injuries as the belt might inflict would be far less serious than the injuries they would sustain in a crash without belts. The urinary bladder should not be allowed to become overdistended, because this is hazardous in any crash situation either with or without belts, and regardless of sex.

We believe that the case of Kulowski and Rost confirms the efficacy of the seat belt in preventing crash deaths and injuries, and that it indicates that abdominal injury by belts is remote. We deprecate the conclusion expressed in the title and regret the influence that this report will have upon the seat-belt idea.

This communication was submitted to Lieut. Col. J. P. Stapp, of Holloman Air Force Base, for his comment. He wrote, and I quote with permission:

"The only experimental injuries to human subjects we have produced was when the lap belt was worn loosely with shoulder straps. In this configuration, the subject tended to slide out from under the lap belt and shoulder straps pulled its upper margin under the lower ribs, causing a fractured cartilage of the left 10th rib in one instance. In our recent experimental series, the lap belt, properly secured and at an angle to impinge on the lower anterior aspect of the pelvis, was worn with little or no discomfort in forward-facing deceleration up to 22 g. It is anticipated that we can go higher without exceeding voluntary tolerance. Numerous animal and human experiments concur with your analysis of the areas of impingement and pressure of a seat belt snugly fastened around the lower anterior aspect of the abdomen with a 45-degree attachment to seat structure or floor."

HORACE E. CAMPBELL, M.D.
537 Republic Building
Denver

The Community Surgeon Looks at General Surgery

In recent years many thoughtful surgeons have recorded their observations concerning the advances of surgery. Inevitably they have been concerned with the education of the surgeon, the expansion of the surgical specialist group, and the various organizations and groups which have influenced American surgery. The community surgeon is greatly interested in these accomplishments and problems, since he is a product of them.

It is at the community level that the mass of this country's surgery is performed. The efficacy of the residency system of surgical training faces reality here. The residency system, which was devised to create teachers of surgery, must now provide not only the occasional great teacher but practicing surgeons. These latter can best answer whether the residency system prepared them for the practice of community surgery. For example, did the training received equip the surgeon for the surgical problems encountered in his practice? Was the time spent in the surgical subspecialties wasted? Of what value was surgical pathology? Was more needed, or less? Was he given sufficient responsibility? Although the learning of operative technique appears to be frowned upon nowadays, did he learn technique? Or was it glossed over as of relative unimportance as compared with time spent assisting a senior in the various projects of the surgical department? Was that time in the laboratory wasted or not? Every community surgeon has very definite opinions concerning these problems.

The general surgeon faces the challenge and encroachments of the specialist. Whereas once the general surgeon was *the* specialist, now he finds himself surrounded by an assortment so varied and all-inclusive that with trepidation and feeling he hopefully prays that at least the abdomen will be left to him! It should be recalled in this regard that to June 30, 1955, the 19 specialty Boards had awarded 60,644 certificates, and, though this is a total figure, it is obvious that a majority still practice and that even the smaller communities are well represented in this trend toward specialization.

Along with the specialist who is commonly certified to be one, the general surgeon must face the American Board of Surgery and evaluate its worth to him. His evaluation may vary from that held elsewhere and yet may be of interest.

There is no doubt that specialists in the various branches of surgery are necessary, valuable, and, above all, here to stay. We are concerned more with the continued expansion of the specialties, when amalgamation would seem more practical, reasonable, and timely. They have picked upon the body anatomic until, in addition to the American Board of Surgery, we have boards which certify in the surgical division of hospital anesthesiologists, neurosurgeons, obstetricians, gynecologists, ophthalmologists, orthopedists, otolaryngologists, pathologists, plastic surgeons, proctologists, radiologists, thoracic surgeons, and urologists. Of course, there are subdivisions, and some of these specialties have

Submitted for publication Dec. 20, 1956.

dissolved into fragments of specialties, and others no doubt will splinter into some form of technical confusion. In all this mélange, only the general surgeon is equipped by training to view the patient, with his various disorders, in proper perspective. This is particularly true of traumatic cases. The patient may awake to find that he has been trephined by a neurosurgeon, tapped by a thoracic surgeon, encased in plaster by an orthopedist, and attached to a bottle by a urologist; but coordination has usually been achieved by the general surgeon, who, of all, first examined him, evaluated the relative importance of his injuries, started therapy, allocated responsibility, and served throughout this trying period as the stabilizing factor in the patient's treatment.

The general surgeon must rise to protest, however wryly, that perhaps the time-honored specialties of neurosurgery, urology, orthopedic surgery, obstetrics and gynecology, ophthalmology, and otolaryngology are enough! We find added to these, in the general surgeon's field, thoracic surgery, proctology, and plastic surgery. Thus, the trained general surgeon—the American Board surgeon—should avoid and respect as in the specialist's province the lungs, the esophagus, the heart, the anus and rectum (and to some minds, the colon), and all the odds and ends which the plastic surgeon reaches for endlessly. This does not seem reasonable or necessary. The patient does not need this form of protection; he must receive protection automatically based upon the moral integrity of the surgeon he selects, who may treat him or refer him properly, whichever is best for the patient.

It has long been recognized that many specialties have produced men not properly trained in basic surgery, e. g., pre- and postoperative care, diagnosis, fluid and electrolyte balance, and the principles of surgical technique. The desirability of general surgical training is now widely recognized by the various specialty boards. This indicates progress up to a point. Actually, there are too many specialty boards, too many specialists, and too much obeisance to this surgical trend. The Report to the American Surgical Association of the Committee on Graduate Surgical Education, presented to the American Surgical Association on April 1, 1953, defined the problems of the specialty boards and demonstrated that the university surgeons were cogniscent of the existing problems. Their solution was to suggest flexibility in the grading of graduate education. The report represents a strategic retreat from present confusion and the assuming of a new position of some strength. It is worthy of study.

It was not until the American Board of Surgery was founded, in 1937, that the general surgeon could face his fellows and proclaim his specialization. The founding of the surgery board stimulated and forced hospitals to provide surgical training programs which would meet the Board requirements. Thus a service was done to young men who wished to become surgeons and directly raised the level of surgical practice everywhere. This has been emphasized in the Report to the American Surgical Association of the Committee on Graduate Surgical Education, previously mentioned. This same report states that the broad scientific nature of the American Board of Surgery examinations has injected an educational aspect into the surgical training programs. It would be more proper to state that too many candidates face the Board after fevered cramming on subjects which were not in their training programs or were given too little attention in the preparation of their training programs. These are known to all Board candidates as the subspecialties, particularly orthopedics, and microscopic surgical pathology and anatomy. It is simply a fact that the Board examines closely in

subject matter which bears little relationship to what the average training program has exposed the candidate. Thus, the candidate after years of surgical training must cram for surgical examinations! It would be a fitting task for the university surgeons to reevaluate their training programs, since the American Board of Surgery continues most wisely, however irritating and reactionary it may be, to examine candidates as though they all had received ideal training.

These important aspects of the American Board of Surgery are often commented upon. Upon leaving the educational level, we find that certification is important in other, more mundane ways to the neophyte. These are its use (1) as a prerequisite for staff, clinic, and university appointments, (2) as a prerequisite for certain specialty boards, and (3) as a prerequisite for membership in certain surgical societies, and (4) the increased pay and preferment in the Veterans Administration, the armed services, and certain state-supported surgical programs brought by its possession. What was once a goal for young surgeons becomes a downright necessity. But it should never be forgotten, as these peculiar advantages of Board certification are mentioned, that the Board surgeon is better equipped to treat patients properly than his less well-trained colleagues.

One advantage of the examinations of the American Board of Surgery is that it forces the candidate to review material which may need to be better established in his mind. Fundamentally, the Board tests knowledge. It has not tested the candidate's ability to acquire future knowledge, to evaluate patients, to make decisions, to assume responsibility, and to develop surgical authority and confidence. It would seem that these attributes of a surgeon which mark his worth to his community can only be tested by his patients and colleagues through the years. Perhaps there is a place here for the American Board of Surgery which has not been exploited. The Board as it presently functions is static. Initially, it gave a terrific stimulus to surgical training, but now its course can be seen as one which inevitably leads to standardization of the product produced. This will inexorably end in mediocre training for the American surgeon. Programs which once were effected to train surgeons and surgical specialists properly are now judged by how many of their men passed "the Boards." This appears to be a trivial goal for an educational effort.

In recent years the American College of Surgeons has been the one organization which the community surgeon can support wholeheartedly. Through its bulletins, its yearly meeting, and, above all, its regional and state society meetings, it obviously is concerned with improving American surgery at every level. No member could fail to be proud of its great accomplishments in the educational field.

As the years have passed, the membership requirements have slowly but surely been tightened. It is apparent that those in authority within the College wish to make the earning of membership more difficult and thus give to membership greater prestige. It should be remarked that perhaps its great strength and authority stem from its broad base among the surgeons and the surgical specialists of North America. A restriction of membership numbers may well have the effect opposite the one desired. The good achieved by the limited membership of the honorary surgical societies filters through to the country's surgeons slowly, whereas the American College of Surgeons is with them constantly.

The standards for required surgical education today are set, directly or indirectly, by the Joint Commission for the Accreditation of Hospitals, the

American Board of Surgery, and the American College of Surgeons. These standards are minimal and are labeled as such.

Carter,[1] a few years ago, outlined a typical Halsted residency system introduced in Cincinnati by George J. Heuer. This is the system which best produces trained surgeons of great capability. All hospitals cannot support such a residency program. When the residency system is set up on the basis of three or four years of surgical training, educational problems mount rather than decrease. Yet it is in this type of residency that most surgeons receive their training.

The general surgeon, no matter where he studies or how long he spends, needs fundamentally the same material. The basic techniques of the subspecialties of orthopedics, urology, gynecology, and neurosurgery must be learned. In a four-year program at least a year must be devoted to this work. If any of these subspecialties must be omitted, the community surgeon can best skip urology. While it is not important for a community surgeon to have the ability to make pathological diagnoses from slides, he who practices surgery without being a bit of a pathologist travels a foggy road. Surgical and autopsy pathology, essentially gross pathology, must be emphasized in surgical programs of any length. A six-month pathology requirement for all by the American Board of Surgery would improve many surgical programs. In a four-year residency this would leave two and one-half years for all the vast material of general surgery. This has been proved sufficient for many surgeons. The characteristics of such training programs have been explored and described repeatedly. The essential factors which never seem to be stressed sufficiently are that if the teaching in such a program is meticulously and conscientiously given, year after year, surgeons will be produced who will be a credit to their training program; second, that the trainees must bring a capacity for work to the program, and, third, that they must be guided in such a fashion that they realize that their residency years were but a beginning, not an end, to their surgical progress.

J. P. Woodhall, M.D.
724 Hemlock St.
Macon, Ga.

REFERENCE

1. Carter, B. N.: Twenty-Years of a Graduate School of Surgery Founded by George J. Heuer, Surgery 23:326-336, 1948.

Case Reports

Spigelian Hernia

HERMAN PEPPER, M.D., and CHARLES L. GERACI, M.D., Redwood City, Calif.

A hernia occurring anywhere in the linea semilunaris and above the inferior epigastric artery has been commonly named Spigelian hernia, after the Flemish anatomist Adrian van der Spigelius (1578-1625). The semilunar line demarcates the route along which the aponeurosis of the internal oblique muscle splits to enclose the rectus muscles. It extends from the lower costal margin to the pubic spine, lateral to the rectus muscle. The hernia is found most frequently below the umbilicus and may reach considerable size. Hernias below the inferior epigastric artery are classified as direct inguinal hernias. Although the occurrence of a Spigelian hernia is undoubtedly rare, more cases have been reported during the last 30 years than in the entire previous literature. Mersheimer and his associates [1] reported on 151 cases in 1951. Since then, isolated cases have been described which were diagnosed as a rule only during surgical exploration or after strangulation.[2-4] No doubt this type of hernia is commoner than is generally assumed, but has remained either undiagnosed or unreported. Two illustrative cases of Spigelian hernia are presented. In the first case the type of hernia was correctly diagnosed preoperatively, whereas in the second case the hernia was recognized only at laparotomy.

Report of Cases

CASE 1.—A 42-year-old white salesman was admitted to Sequoia Hospital on Oct. 5, 1955. He had undergone a right inguinal herniorrhaphy at 7 years of age. One year before the present admission he had noted a small protruding mass in the right lower abdomen. Initially there was little discomfort, but more recently he had noted a moderately severe pain in the area, accentuated by prolonged walking and standing and by lying down. Occasionally a gurgling sound was heard in the region of the abdominal mass. Recently the bulge had increased in size and had become very tender on pressure. Physical examination was not remarkable except for the abdomen, where a round, soft mass measuring about 5 cm. in diameter was found in the right lower quadrant, lateral to the rectus muscle and apparently protruding through the external oblique aponeurosis. On coughing an impulse could be felt. The protrusion could be reduced in the recumbent position. A diagnosis of Spigelian hernia was made, and the patient was operated upon on Oct. 6. A hernial sac, measuring 8 cm. in diameter, was found protruding through a 3 cm. dehiscence in the transversalis fascia along the right linea semilunaris. The sac lay beneath the external oblique aponeurosis and did not extend beyond it. The sac was excised and the fascia closed in layers. The patient was discharged after an uneventful postoperative course. One year later the patient had no complaints, and examination revealed a well-healed wound.

CASE 2.—A 52-year-old woman was first seen four hours before admission to Sequoia Hospital on Aug. 3, 1956. She complained of nausea, vomiting, and severe cramp-like pain in the entire abdomen, beginning suddenly 18 hours before. Although she refrained from taking anything by mouth, she continued to vomit clear yellowish liquid intermittently. Examination revealed an extremely obese patient with no apparent abdominal distention. There were moderate tenderness and rigidity over the entire abdomen. No abdominal masses were palpable. Bowel sounds were hyperactive. A well-healed, old right subcostal cholecystectomy scar was noted. A diagnosis of early intestinal obstruction was made and the patient was hospitalized. About one hour later projectile vomiting occurred. Roentgen examination of the abdomen suggested a mechanical small-bowel obstruction, and gastric suction was instituted. Later examination revealed a firm, tender, immobile deep mass in the right lower abdomen, measuring

Submitted for publication Dec. 7, 1956.

From the Surgical Section of Sequoia Hospital.

Supported by the Research Fund of Sequoia Hospital.

10 cm. in diameter and lying below the level of the umbilicus.

At operation, on Aug. 3, a loop of midileum was found tightly wedged through an opening in the abdominal fascia in the right linea semilunaris. This opening extended into a large hernial sac, measuring 9 cm. in diameter and lying beneath the external oblique aponeurosis. The strangulated intestinal loop was surrounded by a large amount of gelatinous fluid, which was released when the bowel was freed from the hernial sac. The ileum was deeply hemorrhagic but viable, and was returned to the abdominal cavity. Repair of the fascial defect was done, and the patient made an uneventful recovery.

Comment

The causes of Spigelian hernia are obscure. Zimmerman and his associates[5] believe that weak aponeurotic structures separating muscular bands of the internal oblique and transversalis muscles are potential sites of the hernia. River[6] stated that these hernias may originate in split-like defects in the transversus aponeurosis. Other authors[7,8] have suggested that small perforating blood vessels and nerves in the linea semilunaris may weaken the fascia and predispose to the development of a hernia. Koontz[9] also reported a case in which Spigelian hernia was associated with femoral and umbilical hernias. That obesity may be another predisposing factor is suggested in Case 2, in which the patient had an excessively obese abdominal wall.

Since Spigelian hernia usually does not penetrate the external oblique muscle, thus remaining interstitial, it usually remains hidden and is not often diagnosed. No clear-cut symptom complex has been described for such a hernia. The hernia may appear as a mass of encapsulated omentum, presenting a solid tumor with minimal symptoms,[10] or as a small-bowl obstruction with or without a palpable mass. Often, however, the diagnosis can be made easily. A soft, reducible mass will be encountered in the lower abdomen lateral to the rectus muscle, and usually below the umbilicus. After the reduction, a round or oval defect may be felt in the abdominal wall, and occasionally an impulse can be noted on coughing.

The repair of these hernias is usually simple and effective. The palpable mass or defect is approached directly, the external oblique aponeurosis split, and the sac isolated. The sac is usually surrounded by preperitoneal fat, and is found separating the fibers of the internal oblique and transversus muscles. The medial boundary is the lateral border of the rectus muscle. After freeing, ligation, and excision of the sac, the transversus, internal oblique, and external oblique muscles are approximated in layers. In instances in which the muscle layers are thinned or weak, imbrication may be in order. Postoperative care is the same as for any type of hernia repair.

Summary

Spigelian hernia, or hernia in the semilunar line, is probably commoner than is described in the literature. Two cases are reported. One was diagnosed preoperatively, and the other, which caused acute small-bowel obstruction, was recognized during laparotomy. The anatomy, symptomatology, diagnosis, and repair are discussed briefly.

Sequoia Hospital District, P. O. Box 791.

REFERENCES

1. Mersheimer, W. L.; Winfield, J. M., and Ruggiero, W. F.: Spontaneous Lateral Ventral Hernia, So-Called Spigelian Hernia, A. M. A. Arch. Surg. 63:39, 1951.

2. Saita, A.: Spontaneous Strangulated Hernia of So-Called Semilunar Line of Spigelius, Policlinico (sez. prat.) 59:1029, 1952.

3. Rasmussen, H.: Two Cases of Spigelian Hernia, Nord. med. 47:597, 1952.

4. Ignatius, J. A.: Spigelian Hernia, Am. J. Surg. 90:388, 1955.

5. Zimmerman, L. M.; Anson, B. J.; Morgan, E. H., and McVay, C. B.: Ventral Hernia Due to Normal Banding of the Abdominal Muscles, Surg. Gynec. & Obst. 78:535, 1944.

6. River, L. P.: Spigelian Hernia, Ann. Surg. 116:405, 1942.

7. Anzilotti, G.: Contribution to the Study of Ventrolateral Hernia, Arch. ital. chir. 50:107, 1938.

8. Pampari, D.: Case of Multiple Ventral Hernia, Arch. ital. chir. 37:619, 1934.

9. Koontz, A. R.: Hernia in the Linea Semilunaris, Ann. Surg. 35:875, 1952.

10. Larson, E. E.: Spigelian Hernia, Am. J. Surg. 82:103, 1951.

Adenocarcinoma in a Meckel's Diverticulum with Perforation

Report of a Case

G. C. FREEMAN, M.D., Honolulu, Hawaii

The incidence of Meckel's diverticulum is estimated to be from 1% to 2% of the of the population. It is commonly found at laparotomy for unrelated conditions, but causes no symptoms unless pathological changes occur in the otherwise "normal" anomaly.

These changes and their clinical manifestations have been the subject of numerous reports. They include simple inflammation, hemorrhage from ulceration, intussusception with the diverticulum as the leading point, intestinal obstruction due to associated congenital bands, foreign-body or spontaneous perforation of the diverticulum, and others still less common. One of the rarest is the finding of malignancy in a Meckel's diverticulum. This report concerns such a case with the unusual complication of perforation superimposed.

Report of Case

A 32-year-old white man was first seen on Dec. 28, 1953, at 11 p.m. with a history of sudden onset of severe abdominal pain four hours previously, immediately after a large meal. There had been mild attacks of postprandial pain of similar nature for several days, but this attack differed in that, instead of subsiding, the pain got progressively severer and a physician was called. The past history was negative.

On admission to the Queen's Hospital, the patient was acutely ill with severe abdominal pain, causing him to lie with knees drawn up. The significant findings were tenderness and board-like rigidity throughout the abdomen, the former being maximum in the epigastrium, and rebound tenderness in both lower quadrants. Flat films of the abdomen in the supine, erect, and left lateral decubitus positions showed no free intraperitoneal air. The white blood cell count was 12,000 per cubic millimeter, with 88% polymorphonuclear leukocytes. Serum and urine amylase were normal.

A laparotomy was performed immediately under intraspinal tetracaine (Pontocaine) and dextrose anesthesia and intravenous thiopental (Pentothal) sodium. A midline incision permitted adequate exploration of the upper abdomen, revealing the presence of a thin purulent exudate but no evidence of a perforation of gastric or duodenal ulcer. The incision was extended to the lower abdomen, the appendix exposed, and only periappendicitis found. Inspection of the terminal ileum revealed a large Meckel's diverticulum in the usual location, but showing marked inflammatory reaction. The diverticulum measured about 3×6 cm., was thick-walled and coated with fibrin, and apparently had perforated, producing the spreading peritonitis. No foreign body was noted. The nodes in the mesentery of the ileum were not enlarged. Approximately 6 in. of the diverticulum-bearing portion of the ileum was resected and a two-layer end-to-end anastomosis performed. The appendix was removed.

The resected specimen was examined by Dr. Harold Civin, who reported the presence of a Grade II adenocarcinoma of a Meckel's diverticulum, Type C (Duke's). Metastatic involvement of the regional nodes was noted. A portion of his description of the microscopic picture follows:

"Present in a Meckel's diverticulum are nests and sheets of cells, all tending to form papillae. The nests show anisocytosis, poikilocytosis, anisonucleosis, poikilonucleosis, mitotic figures, a tendency to form glands, and deep invasion of the wall (of the diverticulum by these cell masses). There is some acute inflammatory reaction in the wall. The picture is that of a Grade II adenocarcinoma of a Meckel's diverticulum with acute peritonitis. . . . The lesion does not look as though it arose from aberrant gastric mucosa. . . . Section of a lymph node reveals metastases."

The patient's convalescence from operation was marred by the presence of persistent ileus, which only partially responded to intubation with a long mercury-weighted tube. Hydration was maintained with appropriate solutions intravenously. A second laparotomy for the wider removal of the area of the primary carcinoma and its regional lymphatic drainage was done as soon as the patient's

Submitted for publication Feb. 2, 1957.

From the Department of Surgery, Straub Clinic.

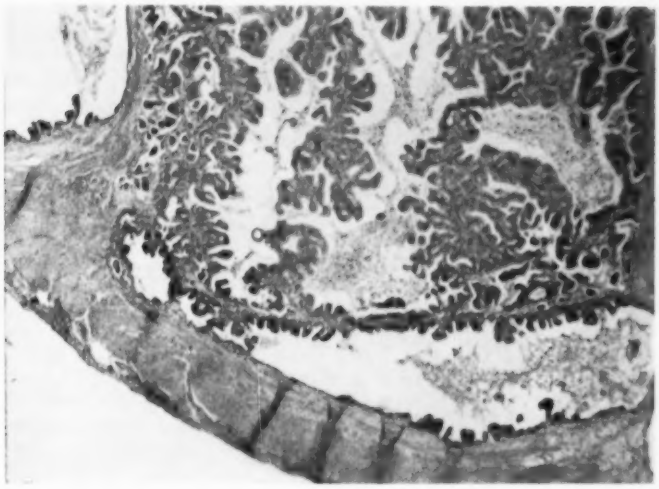
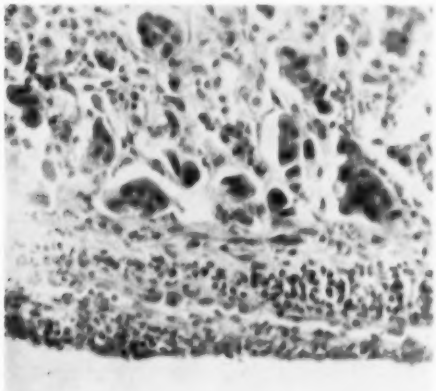


Fig. 1.—Papillary adenocarcinoma within lumen of diverticulum. Hematoxylin and eosin stain; reduced to 88% of mag. × 45.

abdomen was deflated sufficiently to permit it to be done safely. At this second operation, two areas of partial obstruction of the small intestine were encountered, due to early adhesions between loops of ileum, on the one hand, and the closure of the small bowel mesentery and the appendiceal stump, on the other. The site of the previous anastomosis was patent. The ileal mesentery contained a single 2.5 cm. node, which was subsequently sectioned and found to contain metastases. In order to do a satisfactory regional-node resection, a radical right colectomy was done, ligating the ileocolic and right colic vessels at their point of origin, and including all of the intervening mesentery. Intestinal continuity was restored by a side-to-side anastomosis between the ileum and the transverse colon, and the abdomen was closed in layers.

The patient made an uneventful recovery from operation and was discharged on the eighth postoperative day. He was seen in the office at intervals for the next six months, at the end of which time he returned to the mainland. About 14 months after resection, he began to have symptoms of recurrent carcinoma and died in May, 1955.

Fig. 2.—Malignant cells infiltrating wall of diverticulum almost to serosa. Exudate is present on serosa. Hematoxylin and eosin stain; reduced to 88% of mag. × 265.



Comment

Malignancy in a Meckel's diverticulum is rare. Three categories have been reported.

Sarcoma has been the commonest type. Hill and Janelli,[1] in a review of the literature to 1953, found 18 cases of sarcoma previously reported and added 1 of their own. Seven of these were spindle-cell sarcomas, and six were leiomyosarcomas. Barrett,[2] in 1954, reported another case of leiomyosarcoma, making a total of 20 sarcomata found in Meckel's diverticulum to date.

Pierce[3] reviewed the reports of carcinoid tumors of Meckel's diverticulum and found nine such cases, including his own, reported up to 1955. Although the eventual malignancy of carcinoid tumors is generally accepted, only one of those found in Meckel's diverticulum was frankly so. Since this report Grimes and Crane[4] and Stoll[5] have reported additional cases of malignant car-

cinoid of Meckel's diverticulum with extensive liver metastases.

The reports of adenocarcinoma found in Meckel's diverticulum were reviewed in 1953 both by Moore and Parsons[6] and by Hill and Janelli. Their findings agreed that 9 such cases had been reported to that time, and the former authors added a 10th case. The case included in this review, therefore, constitutes the 11th case of adenocarcinoma of Meckel's diverticulum to be reported.

Summary

Cancer in Meckel's diverticulum is a rare finding, but should be suspected if any tumefaction of the anomaly is identified at surgery. In spite of an immediate "second look" and a radical resection of the lymph-node-bearing area, the patient reported here succumbed to recurrent carcinoma. If its presence had been suspected at the first operation and lymphatic pathways containing malignancy had not been violated, his chances for cure might have been somewhat better.

Straub Clinic, Kapiolani St. at Thomas Sq. (14).

Addendum

Since this paper was submitted for publication, two additional instances of carcinoma arising in a Meckel's diverticulum have been reported (Konwaler, B. E., and Wenkle, W. C.: Carcinoma Arising in Meckel's Diverticulum. Report of a Case, Am. J. Clin. Path. 27:76 [Jan.] 1957.

REFERENCES

1. Hill, F. A., and Janelli, D. E.: Malignant Tumor Originating in Meckel's Diverticulum: Case Report of a Leiomyosarcoma and Review of Literature, Am. J. Surg. 85:525 (April) 1953.

2. Barrett, J. C.: Malignant Tumor of Meckel's Diverticulum, Brit. J. Surg. 41:518 (March) 1954.

3. Pierce, R. E.: Carcinoid Tumor of Meckel's Diverticulum, U. S. Armed Forces M. J. 6:1058 (July) 1955.

4. Grimes, O. F., and Crane, V. T.: Malignant Carcinoid Tumor Arising in Meckel's Diverticulum, Am. J. Surg. 90:1020 (Dec.) 1955.

5. Stoll, H. C.: Argentaffin Carcinoma (Carcinoid) of Meckel's Diverticulum with Metastases to Liver, A. M. A. Arch. Path. 56:643 (Dec.) 1953.

6. Moore, P. M., and Parsons, W. H.: Carcinoma in Meckel's Diverticulum, A. M. A. Arch. Surg. 67:939 (Dec.) 1953.

Carcinoid of the Ileum

Unusual Cause of Gastrointestinal Bleeding

LAWRENCE S. MANN, M.D., and ROBERT D. SIMPSON, M.D., Chicago

Malignant neoplasms of the small intestine are rare, comprising 1%-3% of those occurring in the gastrointestinal tract.[2] Malignant tumors of the jejunoileum are twice as frequent as the benign type.[3] One case of every 15 or 20 cases in the malignant group is a carcinoid.[1] Ariel[4] reports an incidence of 8.3% of carcinoid in his series of resected neoplasms of the small intestine. Carcinoids of the small intestine are frequently an incidental finding at surgery or autopsy.

Dockerty[5] and Foreman[6] believe the ileum to be the commonest site of extra-appendiceal carcinoid, whereas Hines, Hanley, and Boese[7] and Mrazek, Godwin, and Mohardt[8] report rectal lesions to be the commonest extraappendiceal source. Of small intestinal carcinoids, 24.9% metastasize, but appendiceal carcinoid usually does not.[4]

Carcinoid of the small intestine produced symptoms in about 36% of the cases and, when symptomatic, was associated with intestinal obstruction and, less frequently, with intussusception.[4] In a review of the literature, we did not find any instance of gross or massive bleeding associated with carcinoid of the ileum, although occult blood has been noted in the stool. Small amounts of bright red blood were passed by patients with rectal carcinoid, and gross bleeding was reported in two cases of extensive cecal carcinoid.[8]

Recorded for publication Feb. 1, 1957.

From the Surgical Service, Veterans' Administration Hospital, Hines, Ill., and the Department of Surgery, Chicago Medical School.

Attending Surgeon, VA Hospital, Hines, Ill., and Clinical Assistance Professor of Surgery, Chicago Medical School (Dr. Mann); Resident in Surgery, VA Hospital, Hines, Ill. (Dr. Simpson).

The following presentation is that of a patient who had seven episodes of melena over a five-year period with a carcinoid of the ileum as the etiological agent.

Report of a Case

History.—A 56-year-old white male physician and surgeon was admitted to the Veterans' Administration Hospital, Hines, Ill., on July 6, 1956, complaining of weakness and having passed tarry stools during the previous 12 hours. There had been no vomiting or pain. He had noted slight tenderness in the right lower quadrant for a period of several months, with no change in tenderness at the time of admission. His past history included seven episodes of having passed tarry stools associated with weakness during the past five years. He had had a myocardial infarction at the time of his first attack and recently noted occasional orthopnea and ankle edema. During one of the bleeding episodes he received 500 cc. of blood. Three complete hospital evaluations of his symptoms were made, one at a prominent diagnostic center and one at this hospital, but no cause for the melena was found or any definitive treatment instituted.

Physical Examination.—Physical examination revealed a well-developed, well-nourished, anxious man, 6 ft. tall, weighing 190 lb., who did not appear to be in acute distress. The patient complained of weakness when sitting but was otherwise comfortable. Blood pressure was 160/110 and pulse, 96. Examination of the heart and lungs was within normal limits except for tachycardia when sitting. The abdominal findings were confined to an area of slight tenderness in the right lower quadrant. Bowel sounds were normal. Rectal examination revealed black stool.

Laboratory Data.—Hemogram: Red blood count, 4,400,000; white blood count, 10,500; hematocrit, 39; hemoglobin, 12.5 gm.; bleeding time, 1 minute 25 seconds; coagulation time, 3 minutes 3 seconds; platelets, 184,000.

Urinalysis: Specific gravity, 1.008; albumin, 1+ (50 mg/100 ml.); sugar, negative; hyaline casts, occasional. Repeat urinalysis revealed a trace of albumin with a specific gravity of 1.010.

Liver Function: Thymol turbidity, 3; van den Bergh's test—direct, 0.2 mg/100 ml., indirect, 0.4

Fig. 1.—External appearance of carcinoid of the ileum.

mg/100 ml.; prothrombin time, 13 seconds (100%); cephalin flocculation, negative.

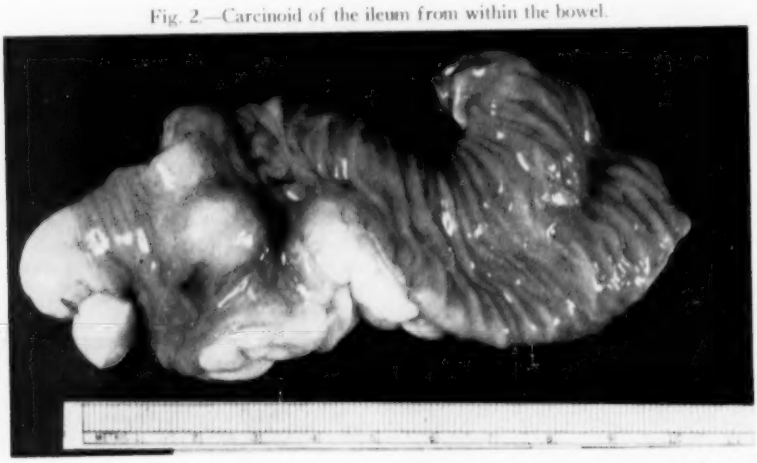
X-Ray: Emergency upper gastrointestinal series, performed on day of admission by Dr. Israel E. Kirsh, revealed no lesion. Barium enema and small bowel series revealed no abnormality. X-ray of the chest showed minimal cardiac enlargement.

Electrocardiogram: Reported as abnormal. Compatible with old posterior wall myocardial infarction and myocardial ischemia with left heart strain pattern.

Hospital Course.—The patient ceased to bleed during the first 24 hours of hospitalization. Two units of blood were used during this period, after which the pulse and blood pressure stabilized. Four additional units of blood were given during the following week to return the patient's blood volume to normal. Complete evaluation was again negative except for impaired renal function, hypertension, and arteriosclerotic heart disease. Because of the recurrent melena and persistent mild tenderness in the right lower quadrant, an exploratory laparotomy was decided upon, in spite of the fact that the patient was only a fair surgical risk from the cardiorenal viewpoint.

With the patient under general anesthesia, an exploratory laparotomy was performed on July 18, 1956, at which time a 2 cm. intraluminal nodular lesion of the ileum, about 2 in. proximal to the ileocecal valve, was found. The lesion was firm and fixed to the muscularis and serosa, being located midway between the mesenteric and the

Fig. 2.—Carcinoid of the ileum from within the bowel.



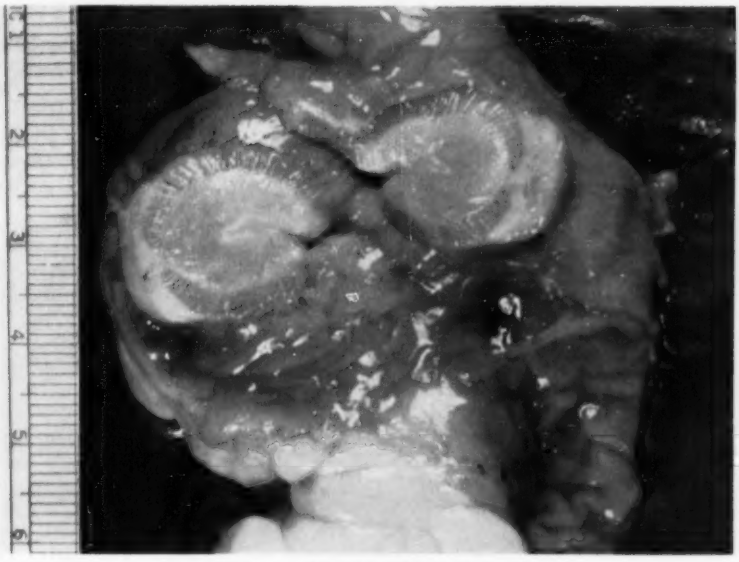


Fig. 3.—Cut section of carcinoid of the ileum.

antimesenteric border. A local resection was performed.

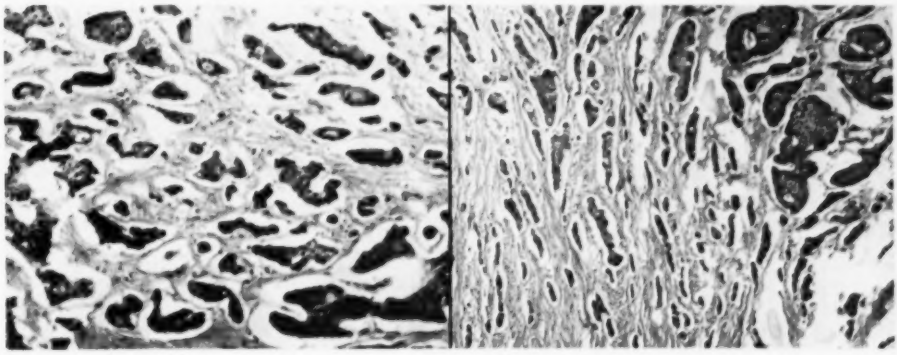
Pathologically the tumor showed a 1 cm. ulcerated area over the mucosal surface. Cut section revealed a gray granular surface. The tumor had invaded the muscularis, so that most of it appeared to lie subserosally. Figures 1, 2, and 3 show the gross appearance of the tumor. The paraffin sections revealed typical carcinoid. A nest of cells was seen infiltrating the muscularis as far as 2 cm. from the primary lesion. The operation was considered inadequate because of this.

Postoperatively the patient had considerable ileus, and obstruction at the anastomotic site was suspected. These factors, combined with inadequate resection, led to a second laparotomy performed on July 26, 1956, at which time the anastomosis was found to be intact and functional. A resection of the terminal ileum, previous anastomosis, and cecum was accomplished. The postoperative course was again prolonged but uneventful. Pathologic study of the second specimen revealed no evidence of carcinoid.

Summary

Carcinoid is a rare tumor of the gastrointestinal tract which is thought to arise from the argentaffin cells. It may be found anywhere in the gastrointestinal tract but is most frequently found in the appendix,

Fig. 4.—Microscopic sections of carcinoid of the ileum.



where the argentaffin cells are most abundant.[4] Once thought to be benign, it is now generally considered to be a malignant lesion. Foreman[6] states that most authors agree that all carcinoids are essentially malignant if they have been observed for a long enough period of time.

Ileal carcinoids are usually asymptomatic but may manifest themselves by intestinal obstruction, pain, diarrhea, and occasionally intussusception. Gross bleeding, to the best of our knowledge, has not been reported as a symptom. A case of carcinoid of the ileum with melena is presented. Small bowel tumors should be considered in the differential diagnosis of bleeding from the gastrointestinal tract.

224 S. Michigan Ave. (4) (Dr. Mann)

REFERENCES

1. Maingot, R.: Abdominal Operations, Ed. 3, New York, Appleton-Century-Crofts, Inc., 1955, p. 1109.

2. Maingot,[1] p. 1104.

3. Maingot,[1] p. 1115.

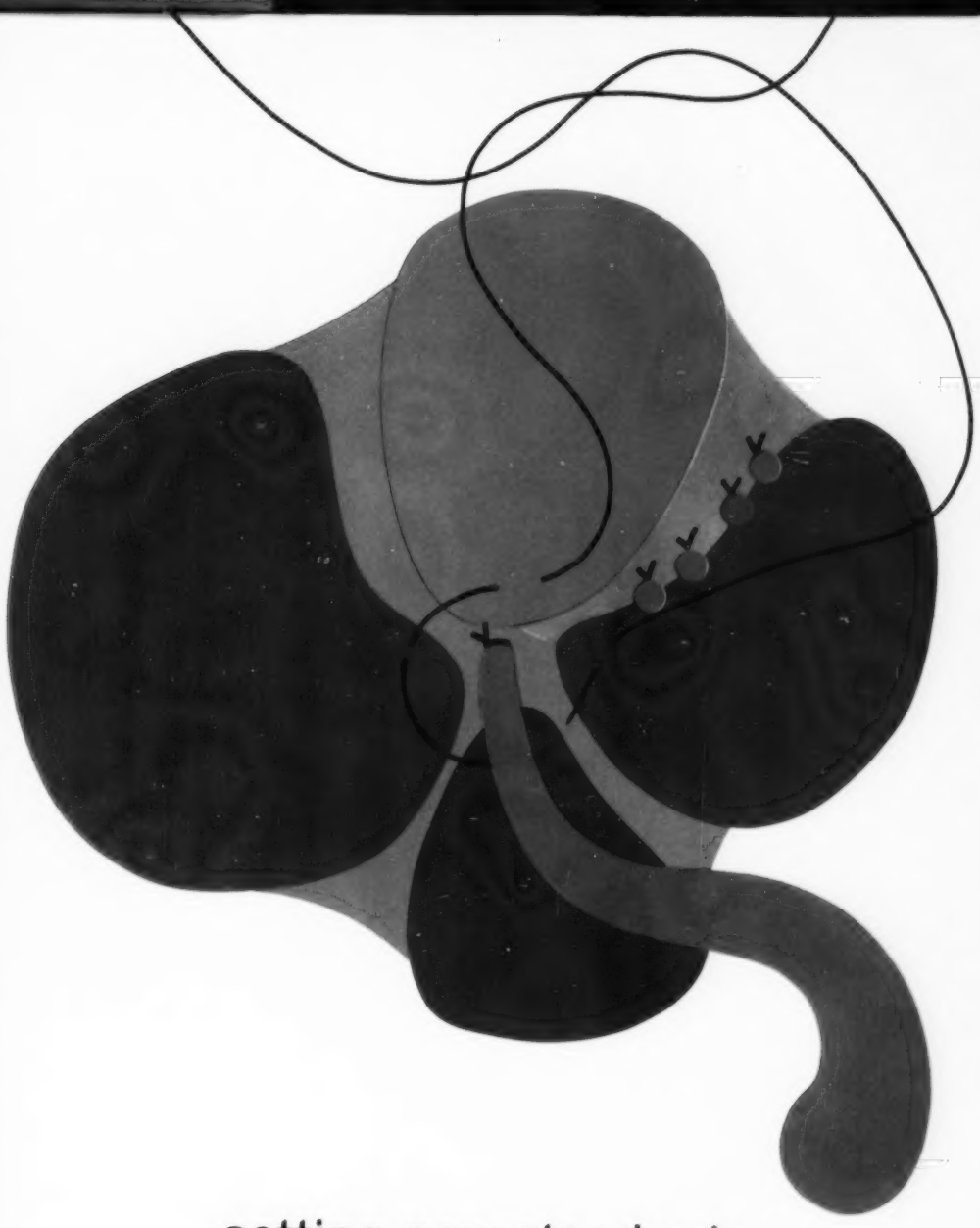
4. Ariel, I. M.: Argentaffin (Carcinoid) Tumors of the Small Intestine, A. M. A. Arch. Path. 27: 25-52 (Jan.) 1939.

5. Dockerty, M. B.: Carcinoids of the Gastrointestinal Tract, editorial, Am. J. Clin. Path. 25: 794-796 (July) 1955.

6. Foreman, R. C.: Carcinoid Tumors, Ann. Surg. 136:838-855 (Nov.) 1952.

7. Hines, M. O.; Hanley, P. H., and Boese, H. L.: Carcinoid Tumors of the Gastrointestinal Tract, A. M. A. Arch. Int. Med. 96:500-506 (Oct.) 1955.

8. Mrazek, R. G., Jr.; Godwin, M. C., and Mohardt, J.: Carcinoid Tumors: Clinical and Pathologic Study of 27 Cases, Surg. Gynec. & Obst. 96:661-673 (June) 1953.



setting new standards

ETHICON®

sutures

greater convenience in obstetrical repair

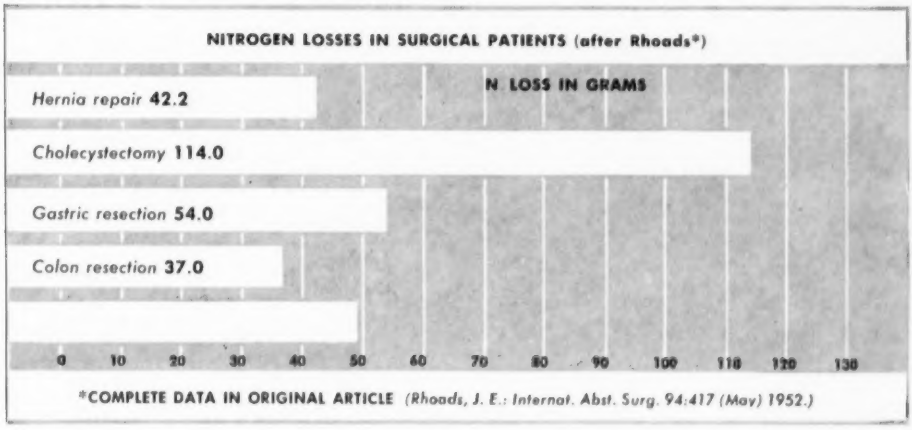
with new double-armed OB sutures

ETHICON®

NILEVAR FOR PROTEIN TISSUE BUILDING

Protein Deficiency, a Hazard in Surgical Patients, Reversed with Nilevar®

With surgery made safe for the patient, the patient may now be made safe for surgery.



Patients about to undergo extensive surgery[1] frequently have negative nitrogen balance and protein deficiency. And after any severe trauma, including extensive surgery, the rate of protein breakdown is increased.

It is also well recognized that patients with a strongly negative nitrogen balance are much more prone to suffer delayed wound healing[2], secondary infections[3], shock[2] and delayed convalescence[4].

The need for an effective protein anabolic agent is stated by Moore and Ball[5]—"there is one unbreakable rule of surgical convalescence: to complete his recovery, regain strength and return to work the patient *must* come into positive nitrogen balance."

Nilevar (brand of norethandrolone) is a new anabolic steroid which rapidly and effectively reverses or diminishes excessive protein catabolism and nitrogen loss accompanying major surgical procedures. The protein anabolic activity of Nilevar is specific. There are usually minimal or no androgenic side effects.

In addition to its use both preoperatively and postoperatively, Nilevar is indicated in all conditions in which excessive protein catabolism (nitrogen loss) hinders or delays convalescence:

Recovery from pneumonia, poliomyelitis, severe burns and fractures, and in the care of premature infants, decubitus ulcers and wasting diseases such as cancer and tuberculosis.

The daily adult dose is three to five Nilevar tablets (30 to 50 mg.). For children the daily dosage is 1 to 1.5 mg. per kilogram of body weight for the first ten days of treatment, after which the daily dosage should be reduced in all prepuberal patients to 0.5 mg. per kilogram of body weight. Individual dosages depend on the need for and the response to therapy. G. D. Searle & Co., Chicago 80, Illinois. Research in the Service of Medicine. References supplied on request.

SEARLE

New, Well Tolerated Medium for Excretory Urography

94%

DIAGNOSTIC FILMS

in a series of 1123 patients

Hypaque SODIUM

50% solution

Write for detailed literature or consult your local Winthrop representative.

Winthrop LABORATORIES

NEW YORK 18, N.Y. • WINDSOR, ONT.

Hypaque sodium, brand of diatrizoate sodium (sodium 3,5-diacetamido-2,4,6-triiodobenzoate)